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This SCHOLARSHIP of £50 a year, tenable for three years by a student who intends to enter some branch of the Engineering Profession, will be OFFERED for COMPETITION at the College Entrance Scholarship Examination which begins on April 20, 1925. Further particulars and a form of application can be obtained from the undersigned, to whom the form of application must be returned on or before March 24, 1925.

D. J. A. BROWN, Registrar.

University College, Cardiff. H 31

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Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St George's Square, London, S.W.1. G 788

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TENDERS.

MANCHESTER SHIP CANAL COMPANY.

The Directors of the Manchester Ship Canal Company are prepared to receive

Tenders from Experienced

Contractors for the CONSTRUCTIONAL STEELWORK to be erected on the site for the COMPANY'S NEW OFFICES, situate on the west side of King Street, Manchester.

Copies of the drawings and schedule with Specification and Form of Tender can be obtained at the office of the Architect for the new offices, HARRY S. FAIRBURN, A.R.I.B.A., 14, Chancery Lane, Spring Gardens, Manchester, on payment of Two Guineas, which is not returnable.

Sealed Tenders addressed to the undersigned and Endorsed "Tender for Structural Steelwork," should be delivered at this office on or before Ten a.m. on the 10th day of February, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

F. A. EYRE, Secretary.

41, Spring Gardens, Manchester. January, 1925. H 30

TO CRANE MAKERS.

THE DUBLIN PORT AND DOCKS BOARD is prepared to receive

Tenders for the Supply and

ERECTION of ONE 3-TON LEVEL LUFFING ELECTRIC PORTAL CRANE.

An outline specification and drawing can be obtained at the Office of the Engineer of the Board, JOSEPH MALLAGH, Esq., Assoc.M.Inst.C.E., East Wall, Dublin, between the hours of Ten a.m. and Four p.m.

Sealed Tenders, marked on the outside of cover "Tender for Electric Crane," must be delivered by post, sealed, prepaid and addressed to the Secretary, Port and Docks Office, Westmoreland Street, Dublin, not later than Eleven a.m., on Wednesday, 18th February, 1925.

The Board does not bind itself to accept the lowest or any Tender.

By Order, R. H. BAILEY, Secretary.

Dublin Port and Docks Office. 23rd January, 1925. H 46

CITY AND ROYAL BURGH OF DUNDEE.

ELECTRICITY DEPARTMENT.

The Corporation invites

Tenders for the Supply,

DELIVERY, and LAYING COMPLETE of the EXTENSIONS to the CIRCULATING WATER SUPPLY and DISCHARGE PIPES, consisting of 30 in., 42 in., and 48 in. diameter cast iron flanged and spigot and faucet pipes.

Copies of the Specification, Form of Tender and General Conditions of Contract, along with Drawings, may be obtained from the undersigned at the Head Office, Dudhope Crescent Road, Dundee, upon the deposit of Two Guineas, which sum will be returned upon the receipt of a *bona fide* Tender.

Tenders (sealed in envelopes provided) to be lodged with the Town Clerk, City Chambers, Dundee, not later than by Twelve Noon, on Monday, 16th February, 1925.

The Corporation does not bind itself to accept the lowest or any Tender.

D. H. BISHOP, B.Sc., M.I.E.E., General Manager and Engineer, Electricity Supply Department, Dudhope Crescent Road, DUNDEE. Monday, 26th January, 1925. H 50

BOROUGH OF HAMMERSMITH.

GENERAL ELECTRICITY STORES.

The BOROUGH COUNCIL invite

Tenders for the Supply of

the following STORES for the period of 12 calendar months, commencing on the 1st April, 1925:—

1. Brooms and Brushes.
2. Electrical Goods.
3. Files.
4. Fire Bricks, Clay and Lime.
5. Insulated Wires.
6. Metals.
7. Oilman's Goods.
8. Steam Packing and Jointing Materials.
9. Tools.
10. Joint Boxes and Connections.
11. Meters (ordinary and prepayment).
12. Screws and Ironmongery.
13. Stoneware Conduit.
14. Insulating Compound.
15. Low Tension Concentric Cable.

Forms of Tender and further particulars may be obtained on application to Mr. F. HILL, Borough Electrical Engineer, 85, Fulham Palace Road, W.6, upon receipt of a stamped addressed brief envelope, and where duplicate copies are required, a remittance of 2s. 6d. must be made.

Sealed Tenders, endorsed "Tender for Electricity Stores," must be delivered to the undersigned, at the Town Hall, Hammersmith, W.6, not later than Four p.m., on Wednesday, 18th February, 1925.

The Council does not bind itself to accept the lowest or any Tender,

HUGH ROYLE, Town Clerk.

Town Hall, Hammersmith, W.6. 26th January, 1925. H 49

COUNTY BOROUGH OF PORTSMOUTH.

SOUTHSEA STORM WATER DRAINAGE.

PUMPING INSTALLATION.

The Council invite

Schemes and Tenders for the

SUPPLY, DELIVERY and ERECTION at the Burgoyne Road Pumping Station, Southsea Common, of TWO ELECTRICALLY-DRIVEN CENTRIFUGAL PUMPS complete with all works in connection therewith, and for the Maintenance of the whole in thorough repair for twelve calendar months from the completion thereof.

Copies of the General Drawings, Conditions and Specification under which Tenders are invited, may be obtained on application (accompanied by the sum of £3, which will be refunded on the return of the documents within seven days or after the receipt of a *bona fide* Tender accompanied by the documents required) to Mr. ARTHUR W. WARD, the Borough Engineer, Town Hall, Portsmouth, from whom any further particulars may be obtained.

Each Tender must be accompanied by Drawings and detailed Specification descriptive of the Scheme submitted by the person tendering and the particular design of pumps, electric motors, etc., he proposes to use.

Tenders, marked "Tender for Pumps, Southsea Drainage," are to be sent in on the form supplied, and must reach the undersigned not later than Ten a.m. on Friday, the 20th February, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

F. J. SPARKS, Town Clerk.

The Town Hall, Portsmouth. 24th January, 1925. H 35

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY OF STORES, ETC.

The Metropolitan Water Board invite

Tenders for the Supply of the

undermentioned STORES, etc., for the periods of six or twelve months, commencing 1st April, 1925, as the Board may decide:

Tender No.

1. Bricks, Firebricks, Cement, etc.
2. Brushes, Brooms and Handles.
3. Cast Iron Pipes and Irregular Castings.
5. Cotton Waste, Engine Wipers and Mutton Cloths.
6. Hemp, Yarn, Rope, House-Flannel, Mats, etc.
7. Hire of Horses, Carts and Petrol Lorries, and supply of Sand and Ballast.
8. Iron and Steel.
9. Bolts and Nuts, Screws, Files, Tubes, Shovels and Picks.
10. Lead, Brass, Copper, Zinc and Glass.
11. Repair of Meters (Siemens).
12. Fuel Oil, Oils (Lubricating), Kerosene, Motor Spirit, Greases, Tallow, etc.
13. Oilman's Sundries, Soap, Tar, Gas Mantles, Metal Polish.
14. Packings, Rubber Goods, etc.
15. Paints, Varnishes, Linseed Oil, Turpentine, etc.
17. Pipelaying Repairs, Alterations, etc.
18. Scrap Iron, Purchase and Removal of.
19. Small Iron, Brass, Gunmetal and other Castings.
20. G.M. Stopcocks and Ferrules.
21. Sluice Valves and Spindles, Hydrants, G.M. Outlets and Caps.
22. Timber, Hard and Soft Woods.
23. Maintenance of Welding Machines.
24. Electric Lamps.
26. Furnace Refuse, Disposal of.

Tenders must be made on the official forms, which may be obtained from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, on and after Thursday, 22nd January, 1925, by personal application (Room 156), or upon forwarding a stamped, addressed brief envelope.

Applicants should refer to the number of the Tenders for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, Clerkenwell, E.C.1," and endorsed "Tender for....," must be delivered at the Offices of the Board (Room 122) not later than Eleven a.m. on Wednesday, 11th February, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER, Clerk of the Board.

Offices of the Board, New River Head, 173, Rosebery Avenue, Clerkenwell, E.C.1. 15th January, 1925. G 989

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for the Supply of :—

1000 TYRES for CARRIAGES and WAGONS, as per specifications to be seen at the Company's Offices.

Tenders, addressed to the undersigned, and marked "Tender for C. and W. Tyres," with name of firm tendering, to be lodged not later than Noon, on Tuesday, the 17th day of February, 1925.

For each specification a fee of 10s. will be charged which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board, E. A. NEVILLE, Managing Director.

237, Gresham House, Old Broad Street, London, E.C.2. 27th January, 1925. H 70

BOROUGH OF BRIDLINGTON.

EXTENSIONS TO ELECTRICITY WORKS.

The Bridlington Borough Council invite

Tenders for the Supply and

ERECTION in their Electricity Works at Brett Street, Bridlington, of the following:—

SPECIFICATION No. 1. ONE 600 K.W. STEAM TURBINE, REDUCTION GEAR, AND DIRECT CURRENT GENERATOR.

A Copy of the Specification can be seen at and obtained from the offices of Messrs. KENNEDY and DONKIN, 8, Broadway, Westminster, S.W.1, on and after Monday, the 2nd February, upon payment of a deposit of £2 2s. (cheque, postal order or money order). An additional copy of the Specification can be obtained upon payment of a deposit of £1 1s. These deposits will be returned after the receipt of a *bona fide* Tender, and on the return of the Specification.

Tenders, on the prescribed Form, enclosed in sealed envelopes, and endorsed on the outside "Extensions to Electricity Works, Tender to Specification No. 1," must be delivered at the office of the undersigned not later than Monday, the 16th February, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

GEORGE MELVIN, Town Clerk.

Town Hall, Bridlington. 24th January, 1925. G 37

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. India Rubber Vibrating Pads.
2. Galvanized Fencing Pales.
3. Miscellaneous Articles.
4. Dog Spikes.
5. Pressed Steel Sleepers.
6. Structural Steelwork (Saw Mill).
7. Goods Wagons (B.G.).

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for India Rubber Vibrating Pads," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 13th February, 19 5, for Specifications Nos. 1, 2, 3, 4 and 5, and on Friday, the 27th March, 1925, for Specifications Nos. 6 and 7.

The Directors do bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of Specifications Nos. 1, 2 and 3, of 10s. for each copy of Specification No. 4, and of £1 for each copy of Specifications Nos. 5, 6 and 7.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD, Managing Director.

91, Petty France, S.W.1. 27th January, 1925. H 72

NOTICE TO CONTRACTORS.

RECONSTRUCTION OF ANNESLEY BRIDGE.

The Commissioners of the County Borough of Dublin invite

Tenders for the above Work

to be carried out in accordance with the plans and specifications, copies of which can be obtained at the office of the City Treasurer, Lord Edward Street, Dublin, on and after 2nd February, on payment of £1 1s., which will be refunded on receipt of a *bona fide* Tender.

Tenders, addressed to the Commissioners of the County Borough of Dublin, Streets Section, Castle Street, Dublin, and endorsed "Tender for Reconstruction of Annesley Bridge" should be received not later than 24th February next.

The Commissioners do not bind themselves to accept the lowest or any Tender.

JOHN J. MURPHY, Town Clerk.

City Hall, Dublin. 27th January, 1925. H 75

APPOINTMENTS OPEN.

CITY AND COUNTY OF NEWCASTLE-UPON-TYNE EDUCATION COMMITTEE.

ATKINSON ROAD JUNIOR DAY TECHNICAL SCHOOL.

(Headmaster: Mr. JAS. W. BUCKHAM).

Required, for 1st May, 1925,

JUNIOR FORM MASTER; graduate qualified to take Mathematics and Experimental Science. Ability to teach Physical Training and Games essential. The Committee now pay the Burnham Technical Salary Scale, less five per cent.

Forms of Application (which may be obtained by forwarding stamped addressed foolscap envelope) to be returned to the undersigned *not later than FRIDAY, the 13th FEBRUARY*, 1925.

THOS WALLING, Director of Education.

Education Offices, Northumberland Road. H 78

Wanted, for Large Works in

the Midlands, Thoroughly Experienced ENGINEERING FOREMAN who has had extended knowledge and control of refined precision chemical engineering plant, and who is well skilled in the maintenance and upkeep of this class of equipment, together with the control of labour. Good prospects for suitable man.—Address, in confidence, stating age, experience and salary required, H 76, Offices of ENGINEERING.

Oil Engine Designer Wanted

by prominent oil engine manufacturer in the United States. Must be qualified to design both horizontal and vertical two-stroke cycle engines of the airless injection cold-starting type, in sizes of 50 to 500 HP.—Address, giving full particulars of experience, education, age and salary, BOX 368, McGRAW-HILL PUBLISHING CO., LTD., 6/8, Bouverie Street, London. G 943

Architect Required by

the GOVERNMENT of SIERRA LEONE in the PUBLIC WORKS DEPARTMENT for two tours of not less than 12 nor more than 18 months' continuous residential service. Salary £600 a year. Free quarters and passages and liberal leave on full salary. Candidates, aged 28-35, should have served articles with a Member of the Royal Institute of British Architects, and have passed the examination qualifying for Associate Membership of that Institute, or possess the Diploma of some recognised college which is accepted by that Institute as exempting candidates from taking the examination of the Institute. Must be first-class Draughtsman, capable of designing and carrying out buildings, taking out quantities, preparing details and specifications, and must be competent to execute building surveys, set out buildings and lay out roads.—Apply at once by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, quoting M/13190. H 81

Assistant Locomotive

SUPERINTENDENT REQUIRED for the NIGERIAN GOVERNMENT RAILWAY, for two tours of from 12 to 18 months' service, with prospect of permanency. Salary £480 a year for the first three years, then £510, rising by annual increments of £30 to £720 and thence by annual increments of £40 to £920. Outfit allowance of £60 on first appointment. Free quarters and first-class passages and liberal leave on full salary. Candidates, age 25 to 35, should be of good education and preferably possess an approved Engineering Diploma. They should have had a thorough training in the workshops of a British Railway or well-known Locomotive firm, should be conversant with the repair and erection of locomotives, carriages and wagons, and be well up in drawing office work and have had running experience. Preference will be given to applicants who have acted in a supervising capacity.—Apply at once by letter, stating age and particulars of qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/Nigeria 13150. H 79

JODHPUR RAILWAY.

JUNIOR LOCOMOTIVE OFFICER.

Messrs. RENDEL, PALMER AND TRITTON, Consulting Engineers to the above Railway, are prepared to receive

Applications (by letter only)

from duly qualified Candidates for APPOINTMENT to the above VACANCY.

Applicants must be Public School men, about 25 years of age and unmarried, and must have a good technical education at some recognised Engineering College, and have passed the Associate Membership Examination of the Institution of Civil Engineers, or the Associate Membership Examination of the Institution of Mechanical Engineers, and have served either a pupilage or apprenticeship in Locomotive Shops in the United Kingdom, together with some drawing office experience. Preference will be given to one who has also had experience in the running department and/or of traffic working.

SALARY, Rs. 535 per calender month to commence, rising according to the scale laid down by Government of India Rules (approximately Rs. 50 per month annually). Salary commences on day of embarkation for India.

TERMS: A three years' agreement in the first instance, first-class free passage to India, and by rail to Jodhpur. The selected candidate will be required to pass a strict medical examination before final appointment.

Letters of application, giving the candidate's age, details of general and technical education, training and subsequent career (in chronological order) with dates, accompanied by COPIES ONLY of testimonials, Army Certificates, etc., should be addressed to Messrs. RENDEL, PALMER AND TRITTON, Appointments Department, 12-14, Dartmouth Street, Westminster, S.W.1, not later than the 13th February, 1925. H 71

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY

THREE TEMPORARY ASSISTANT ENGINEERS.

The Directors are prepared to receive

Applications (by letter only)

for APPOINTMENT to the above POSTS on the Company's Railway in India.

Candidates should be between 24 and 28 years of age, and must have had a good general and technical education, and have obtained a degree at a recognised Engineering College, or have passed the Associate Membership Examination of the Institution of Civil Engineers. In addition they must possess at least one year's practical experience with a Railway Company or on Public Works.

SALARY:—Rs. 450 and upwards per calendar month according to age.

TERMS:—A three years' agreement in the first instance first class free passage to India, and home again on satisfactory termination of services.

The selected candidates will be required to pass a strict medical examination by the Company's Consulting Physician before appointment.

Applications, giving full details of candidate's career, in chronological order (with dates) together with COPIES ONLY of testimonials, etc., must be addressed to the undersigned not later than the 20th February, 1925.

S. G. S. YOUNG, Secretary.

Offices: The White Mansion, 91, Petty France, Westminster, S.W.1. 28th January, 1925. H 83

Wanted, a Thoroughly

Capable DESIGNER to undertake the design of a complete range of Cylindrical and Surface Metal Grinding Machines. The position offers good prospects to a well qualified person. State experience and salary required. Confidential. —Address, H 34, Offices of ENGINEERING.

Engineer, accustomed to

preparing Tenders for Turbine Plant and Power Station Equipment. Application, stating age, training, experience and salary required. —Address, G 976, Offices of ENGINEERING.

WIND STRESSES IN STEEL MILL BUILDINGS.

By ROBINS FLEMING.

(*Concluded from page* 69.)

Mill Building Bents without Kneebraces.—In buildings with travelling cranes, kneebraces can seldom be used. With the gusset plate connecting truss to column made as large as the crane clearance will allow, it is often necessary to obtain lateral stability elsewhere than wholly from the transverse strength of the bents. An effective way, when it can be used, is to transfer all transverse thrust to the ends of the building by means of bracing in the plane of the bottom chords of the roof trusses and thence by diagonals to the ground, or at least to distribute it over several bents. Fig. 4 shows a system of bottom chord bracing for a building 80 ft. wide and 8 bays of 20 ft. = 160 ft. long. If the building were, say, 60 ft. wide and 140 ft. long, with 20 ft. bays as before, the arrangement of bottom chord bracing would not be so simple a matter. The writer submitted the case to six engineers, each experienced in the design of mill buildings. Fig. 5, or some slight variation thereof, is the concensus of opinion on what should be used.

The late P. L. Wolfel was an advocate of what he called "table" bracing, and for the building of Fig. 4 would have used the system shown in Fig. 6. While efficient, the system is more expensive than need be. Advantage is not taken of the full width of the building for the depth of the horizontal truss. If the vertical legs of all angles must be turned up to gain headroom a gusset plate connection is required at all crossings.

Bracing systems in the plane of the bottom chords have their limitations. Openings in the ends may interfere with diagonals being extended to the ground. Once in a great while a building requires provision for longitudinal expansion and contraction, which precludes bracing carried to the ends. If a building is at any time extended at either or both ends the bracing should, of course, be extended to the new end. In a recent case a building had been extended three times in 20 years, the bracing each time being carried to the end. Finally, owing to jib cranes and the open end of the last extension, the whole system had to be replaced.

It should be noted that bottom chord bracing is needed to resist the vibration due to travelling cranes. When this is the main function of the bracing the designer is obliged to rely largely upon his observation and experience in deciding the sizes of members to be used, due attention being paid to the capacity and speed of the crane.

In some instances the lateral loading has been divided between the transverse bents and the bottom chord bracing. With this method there is considerable uncertainty, as the proportion of loading carried by each depends upon their relative stiffness. Despite the uncertainty it is at times advisable to have the transverse bents strengthened for lateral loads in addition to a system of bracing in the plane of the bottom chord. Both may be needed. One engineer in designing high buildings with heavy cranes raises the truss 2 ft. more than necessary for vertical crane clearance, in order to allow the use of substantial gusset plates 3 ft. or more deep in connecting trusses to columns.

In all cases, including roof trusses resting on walls, some diagonal bracing should be introduced into the planes of both top and bottom chords for stiffness, as well as to take calculated stresses. Such bracing is also a necessity to the erector.

Existing Structures.—In applying the foregoing methods to existing structures it will be found that many buildings and roofs are standing that apparently have no right to do so. Moreover, if stresses are calculated in accordance with the needlessly severe assumptions of many textbooks, certain members will often be found stressed to exceed not only their elastic limit, but their ultimate strength. It may be admitted that practice is often reprehensible, but theory based on assumptions not likely to be met is unsound.

In the consideration of buildings that stand up year after year, seemingly in defiance of theory, two things should be remembered: first, the building may never have been subjected to a severe wind—buildings are often so located that the force of the wind is broken before it reaches them; secondly, in every building there are a number of indeterminate sources of strength. Beck in his "Structural Steelwork," London, 1920, pertinently writes, "As a fact, there are two resistances which, though seldom taken into account, help to provide stability; these two resistances are: (1) the partial 'fixity' as to direction of the purlins where they are connected to the trusses, tending to prevent the closing and opening of the angles (made by the purlins with the top chord of the roof trusses); and (2) the resistance of the roof covering to distortion. Of the two resistances, the latter is probably by far the more effective. . . . It would be practically impossible to demonstrate by mathematical reasoning, the extent to which the covering material of a roof is capable of acting also as wind bracing." Nevertheless, as the author states, if rigidly attached to purlins there is a "bracing effect" in the covering. What he says in conclusion applies to the whole subject of wind bracing: "The decision must be made by the

Fig. 4. BRACING-PLANE OF BOTTOM CHORDS.

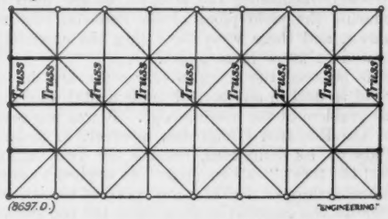


Fig. 5. BRACING-PLANE OF BOTTOM CHORDS.

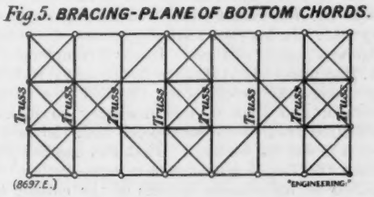
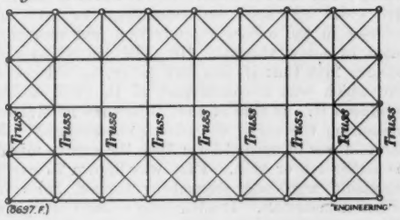


Fig. 6 "TABLE" BRACING-PLANE OF BOTTOM CHORDS



designer, after careful consideration of each individual case and its circumstances; but in all cases it is assumed that the designer is qualified to consider the circumstances, interpret their significance properly, counting the reasonableness of any assumptions made and judging without bias whether any particular risk should be provided for, and to make a decision which can be justified by logical reasoning and by the observation and interpretation of facts in similar cases of previous practice."

Miscellaneous Points.—The assumption of equivalent uniform loading is not applicable to armory roofs or to many of the roofs designed by architects for artistic effect. For such cases separate stress diagrams for wind, snow, and dead loads are usually required.

The proportioning of columns to resist combined axial and bending stress is not within the province of this article. See, however, *Engineering News-Record*, February 24, 1921, page 336; November 9, 1922, page 788; Bishop, "Structural Drafting," page 215.

As the extreme wind loading occurs but seldom and is not long continued, working stresses due to wind either alone or combined with other loads may be safely increased to a maximum of 24,000 lb. per square inch in tension and 24,000 — 105 l/r in compression, provided the section thus obtained is not less than that required if wind forces be neglected. These larger working stresses are not intended to apply to the assumption of equivalent uniform loading.

Girts or side purlins may usually be designed as beams to withstand 15 lb. per sq. ft. wind pressure using a working stress of 24,000 lb. per square inch. It is true that scores of buildings with girts of single angles in which for a pressure of 15 lb. the fibre stresses would be 35,000 lb. to 40,000 lb. per square inch have safely resisted wind for many years. It is probable that if an occasional girt should bend little harm would be done. Nevertheless, the practice of using such girts is not to be commended. In regions of exceptionally high winds 20 lb. pressure, or even more, should be used.

It should be noted that wind blows on ends of buildings as well as on sides. Bracing in the planes of the top and bottom chords of each end bay and carried to the ground in the planes of the side columns will take care of the induced stresses. Buildings have been wrecked when partly erected because no provision was made for wind in all stages of construction. Angle or other stiff bracing should be used in the plane of the bottom chord. It is more or less of a problem to decide upon sizes to be used when stresses are nominal and members are used mainly for stiffness. A well-known fabricating firm places the maximum length for members in compression carrying no calculated stresses at 210 l/r and for angles in tension at 90 times the depth of the angle.

In a Warren system of bracing, members should be designed for compression as well as tension. It is seldom economical or advisable to use a Warren system.

The detailer plays an important part in making any design efficient. Especially is this true of the provision he makes for bending moments of columns and for connections of kneebraces. An excellent design may be weakened by poor details. Common faults in kneebrace connections are (*a*) they pull on the heads of only a few rivets, (*b*) the outstanding legs of the clip angles are weak in bending, (*c*) the joints are very eccentric, (*d*) the joints are weak in compression due to thin gusset plates. It is sometimes economical to design short kneebraces with 5-in. or 6-in. legs to make room for rivets in the ends. A common fault in the details of bottom chord bracing where wind loads are carried to the ends of the building is too few rivets in the connections of diagonals in end bays. The same fault is sometimes found in the vertical diagonals adjoining the corners of buildings.

The anchorage, including anchor bolts and their connections, should be designed and detailed to resist the bending moments at the base of columns. Trusses bearing on walls, when liable to wind pressure on the under side of the covering, should be anchored to resist the uplift. (Suction on the leeward side is also claimed by some to cause an uplift). Usually a pair of vertical angles riveted to the heel of the truss and with outstanding legs embedded in the wall is sufficient for tying wall and truss together.

Building codes, if interpreted literally, are sometimes needlessly severe. In one city a ruling was made that the longitudinals in the plane of the bottom chord should be considered columns and the l/r should not exceed 120. Ridiculously large struts were required for the particular building considered. To meet similar cases of nominal stresses in light structures the writer has inserted in his specifications a provision, "Any portion of the cross-section of a compression member may be neglected in computing the radius of gyration, provided that portion is neglected in the design of the member." This allows the web of beams, and in double angle struts a portion of each leg about the root, to be ignored in determining the radius of gyration. Where advantage is taken of this provision the l/r should be limited to not greater than 160. Eccentricity and bending should be considered in all cases.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution was held on Friday last, the 23rd inst., at Storey's-gate, Westminster, Mr. W. H. Patchell, the President, occupying the chair.

ELECTION OF OFFICERS.

The Secretary announced that, in accordance with Article 23, at the next general meeting, the President, two Vice-Presidents and seven members of Council would retire.

The Council nomination list was then read, as follows: As President, Sir Vincent Raven; as Vice-Presidents, Engineer Vice-Admiral Sir George Goodwin and Mr. Loughnan Pendred; as members of Council, Mr. James Brown, Mr. A. E. L. Chorlton, Professor E. G. Coker, Lieut.-Col. Davidson, Mr. Walter Fanghaenel, Mr. E. C. Marks, Sir A. Ross, Major Thompson and Mr. P. V. Vernon. No additions being suggested by members, the President stated that the ballot on this list would be taken at the next meeting.

CUTTING TOOLS RESEARCH.

Two papers were down for reading and discussion. These consisted of reports made to the Cutting Tools Research Committee of the Institution. The first was entitled "Report on the Flow and Rupture of Metals During Cutting" and was prepared by Dr. Walter Rosenhain and Mr. A. C. Sturney, of the National Physical Laboratory. The second paper bore the title "Report on an Experimental Study of the Forces Exerted on the Surface of a Cutting Tool," submitted by Dr. T. E. Stanton and Mr. J. H. Hyde, of the National Physical Laboratory. Both the above reports were presented in summary by the authors. We reprint them on pages 148 and 151 of the present issue.

Sir John Dewrance, as Chairman of the Cutting Tools Research Committee, said that the experiments referred to were carried out at the instance of the Cutting Tools Research Committee of the Institution, and others would be read before the Institution in due course. He thought the fact would now be appreciated that the edge of the tool did not cut the metal at all. He considered the edge did not cut even with a very light cut, because many years ago when he was in the works, he noticed that when he had finished the surface of a crystalline material like bronze, the face of the work had a crystalline appearance, showing the crystals of the metal, and they differed in different parts of the structure of the work. By suitably lighting the surface and by a considerable exposure he was able to get a very clear and definite photograph of the exact crystals. From this experience, he assumed, that although the cut was as small as one-hundredth of an inch in depth and one-hundredth of an inch in width, and a very sharp tool indeed was used, the metal was really torn off the work. When the cut came to the eutectic it treated it in one way and when it came to the crystal it treated it in another way, which the actual edge of the tool could not have done.

Mr. William Taylor said that hitherto research on cutting tools had been almost wholly confined to heavy cuts and to consideration of the tool as an instrument for removing metal by the ton. A very large part of mechanical engineering work consisted, however, in getting accuracy and fine finish. In dealing with fine cuts one realised more and more that the structure of the metal that was being cut had a very profound effect upon the action of the tool; that was more so with fine cuts than with heavy cuts. Professor Coker, who had done much work in the way of representing stresses, was asked by the committee if he could show them, by cutting celluloid perhaps with glass tools, the distribution of stresses in the material and the tool. In order to simplify the matter it was suggested that he should use a disc from a plain sheet with a perfectly straight cutting edge. Mr. Edward Herbert started the practice of making the cut on the end of a tube. That had the advantage that it had one cutting speed which was unchanged during the progress of the work. Dr. Rosenhain had used that system of cutting on a disc and Dr. Stanton had used the system of cutting on the end of a tube. Dr. Rosenhain had been asked to show, as he had done by his beautiful series of photographs, how the stresses in the metal took effect in distorting the material as it was cut. He had shown the effect in the plastic flow of the material and in an ultimate shearing, but there were many other points that the committee desired to follow up. Between the chip and the tool energy and friction were lost, and the committee had asked Dr. Stanton to estimate for them the losses in friction and energy. He had always thought that glass was incapable of being cut. He did not know what Dr. Rosenhain's view was on that subject, but personally he found that in cutting glass the cutting edge could never penetrate the material so as to decide the point of separation of the chip and the work. He supposed that was because the yield stress corresponded closely with the ultimate stress. There was no plastic movement possible in glass. The same was almost true of hardened steel. When it came to a question of cutting those materials many other effects complicated the issue. Taking, for example, the cutting of metals at high speeds, and the extreme case of the cutting by an abrasive disc running at something like 10,000 ft. a minute, the metal came off in showers of sparks red hot. How far the work done in the chip increased its temperature and facilitated the removal of the chip by reducing the yield point of the material was not known, and those were the things the committee wanted to know more about.

He believed the Institution was the first in the world to deal in any sort of fundamental way with the problem of the cutting edge. It was necessary for the Research Committee, however, to make a study of its definitions, because the two authors used the term "cutting angle" as applied to quite different things. Dr. Stanton spoke of the cutting angle as the enclosed angle between the top surface of the tool and the front surface of the front rake, while Dr. Rosenhain called the cutting angle the top rake. In his (Mr. Taylor's) opinion the cutting edge was neither of these. It was a complement to Dr. Rosenhain's top rake, and he thought it included the front rake except when the tool was feeding forward, and then it was necessary to make a deduction from it to correspond with the rate at which it was fed forward. That was another point which the Research Committee must discuss. He desired to make some defence of the cutting tool from the point of view that it was the business edge which really did the work. It was thirty or thirty-five years ago since he commenced to take an interest in the accurate production and measurement of screw threads. He then discovered the curious fact that it was rare to get in a lathe a cut which was a counterpart of the tool which produced it. It was at that time that he started measuring the screw thread trigonometrically. If the tool was of normal form, then the groove might be either fat or thin. That was known to every mechanic who had reamed or tapped holes in different materials. If a hole was reamed in a piece of phosphor-bronze with an ordinary reamer, generally a wrench would be required to take the reamer out again, which meant that the hole was smaller than the reamer. That, he thought, went to controvert Dr. Rosenhain's statement that the material was always cut clear of the tool. If a hole was reamed in carbon-tool steel just the same thing would be found, and it was true also of tapping holes in those materials. On the other hand, if a hole were reamed or tapped in a piece of cast-iron the tap could be turned out with the fingers or it would fall through. That also occurred in the instance mentioned by Sir John Dewrance. He was cutting a highly crystalline material, and it was true such material cut clear of the edge of the tool. But if it was true that the material always cut clear of the edge of the tool, why was it that the edge of the tool got worn, as it did?

Dr. Rosenhain had one indicator to measure the movement of the tool on the saddle of the lathe, and he put another indicator to measure the spring of the work on the bed of the lathe, so that he had ignored any spring of the bed. While he had criticised several points of Dr. Rosenhain's paper, he desired to say that he was lost in admiration of the photographs given, because they revealed a great deal of information to the members. Dr. Rosenhain had shown three types of chip. Did Dr. Stanton's observation show that there was any abrupt change in the forces on the tool when a change was made from one type of chip to the next? Was it a continuous or a discontinuous change?

Professor W. E. Dalby said he could quite confirm, from some work he did last year, the suggestion that in front of the tool a wedge of the material itself was formed. He was dealing with another aspect of the question, namely, a method of hardening a cutting tool. He was endeavouring to find a method of hardening a cutting tool without first of all producing Martensite in the structure in order to avoid all those stresses which were obtained from sudden quenching. He got a great many of these tools made and dealt with them at different temperatures, and he found that gradually, when the cutting angle was correctly formed, in every case he obtained in front of the tool a kind of wedge of the material, such as was shown in the micro-photographs. Tools formed and hardened in that way stood up to the work, but otherwise they would not stand up and very soon gave out. He was therefore quite prepared to support Dr. Rosenhain's theory of the deformed zone.

Mr. P. V. Vernon, who spoke next, said Dr. Rosenhain's method of showing the chip on the work was, so far as he knew, novel, and he regarded it as most ingenious and valuable. To him the term "cutting angle" meant nothing at all. If he were told by a man that he had a cutting angle of 50 or 40 deg., he would not understand what was meant. It was useless to talk about the cutting angle unless the clearance angle were also known. As it was difficult to carry the two figures in mind at the same time, why not talk about the "top rake angle"? It was that which determined the performance of the tool. The tool was prevented from interfering with the work by the clearance angle. The clearance could be more or less constant—5 to 7 deg. was useful. He would suggest the abolition of "cutting angle" and the adoption of "top rake angle." He gathered that Dr. Stanton had worked with clearance angles of 10 deg.; that was excessive, and with a tool intended to do any appreciable amount of work a very short life would be expected of a tool so shaped. In Dr. Rosenhain's report mention was made of a clearance angle of 20 deg., which, of course, was worse. It would be interesting if, in the final report, Dr. Stanton would give some comparison of his figures and those of Nicolson.

With regard to speed of the work and its relation to the pressure on the tool, he thought that Dr. Stanton only half agreed that the pressure and speed were independent of one another. In the discussion of a paper read before the Institution some time ago he had given a number of figures, from which it appeared that for all practical purposes the speed of the work did not affect the pressure on the tool. He thought that the results obtained by small cuts should be compared with the figures obtained by larger cuts, and it would be very interesting to see to what extent the results obtained by Dr. Rosenhain on very small cuts would conform to bigger cuts and to heavy cuts—particularly at higher speeds. He quite realised the difficulty in stopping the lathe, but he thought this could be done, at very much higher speeds than had hitherto been attempted.

With regard to the cutting edge, he did not desire to express a very definite opinion, but it might be of interest to know that in the manufacture of screw gauges with a precision lathe it was possible and usual to take a 2/10,000 in. deep cut; if therefore the cutting edge did not cut it was very near the point. In connection with the cutting of brass, Mr. Vernon had observed that part of the experiments had been made with a top rake of 30 deg. Whether that would help in the future he could not say, but it was quite new to him to learn that brass was cut at 30 deg.; it was usual with brass to use no top rake at all, and the chips flew away from the work the moment they were produced. The top rakes in both sets of experiments went up to 30 deg. He would like the experiments to be carried

further, for it was quite common to turn steel bars on turret lathes with a top rake of 35 deg.

Mr. H. N. Gresley said, with regard to the question of wear on the edge of the tool, he would like to ask how Dr. Rosenhain accounted for the fact that the edge of the tool did undoubtedly wear. If it did no work, and was not in actual contact with the material being removed, why did the edge of the tool require re-grinding? With regard to the wedge shown in Dr. Rosenhain's diagram, this wedge appeared to form part of the material and was not in any way separated from it. In turning material like hard tyre steel, having perhaps 50 to 55 tons tensile strength, after a certain amount of work had been done it would be found that a wedge, very similar in shape to that shown on the diagrams, was adhering to the top of the tool and did not form part of the material. He had difficulty therefore in understanding how, in one case, the wedge appeared to be part of the stock, while in the others it adhered to the tool. That might be due to the action of cutting on different classes of material. He believed that the action of the cutting tool on hard steels was entirely different to the action on mild steels. He thought the research was likely to lead to most interesting and useful results to practical engineers.

Mr. R. C. Macdonald said he recollected an experience with a special job in a planing machine, carried out with the aid of a parting tool. The work was parting to a depth of about 15 in. in a block of mild steel. An ordinary parting tool having normal cutting angles was used. At a depth of 12 in. cutting was regular, but pronounced chattering of the tool took place. This condition continued when the tool was set well back with the cutting edge in line with the back of the tool. If no clearance were allowed on the cutting edge of the tool, however, for a depth of cut of about $\frac{1}{16}$ in., chattering ceased. It seemed probable that the excessive clearance on the tool used in Dr. Rosenhain's experiments might have assisted in causing the radial fracture of the metal bar. He suggested that the best way to obtain conditions required by Dr. Rosenhain's experiments would be by rapidly reversing the lathe and removing the tool simultaneously.

Lieut.-Col. E. Kitson Clark inquired whether it would be possible to secure photographs of the effect of a hammer and chisel on microstructure. Regarding the metal in contact with the tool, his experience had been that the wedge was not always of the shape indicated by Dr. Rosenhain's experiments; the pieces of material had been rather more curved and rather thinner. He thought the material was broken off by leverage at a certain distance from the working surface; the crack preceding the tool.

Mr. E. R. Dolby inquired whether the cutting action was not similar to that observed when driving a wedge into timber. Here the split usually preceded the wedge. With regard to the material adhering to the nose of the tool, was it argued that part of the metal stuck to the nose of the tool permanently, as suggested by Mr. Gresley, or was it suggested that certain particles adhered temporarily to the tool before passing forward? If they passed forward, did they stick to the chip or did they drop down as powder?

Mr. F. E. Robinson said that from observations he had made when cutting with carbon steel, tungsten and high-speed steels, he found quite different characteristics. In the case of ordinary carbon steel there was no appreciable crowding of metal on the tip of the tool. With 4 per cent. tungsten steel there was a certain amount of crowding. In the case of steel where lubrication was used, it did not occur. In machining brass, however, it occurred to some extent, but the tip formed was easily removable by the stone, and the tool retained its cutting edge a long time. Building up on the tool occurred with high-speed steel. He did not know that anyone had ever analysed the composition of the crowded area in the case of high-speed steel. The brass used by Dr. Rosenhain was not ordinary commercial 60–40, but what was known as "lead-free" brass, which gave results entirely different from those obtained with ordinary 60–40 brass, containing, usually, about 1 per cent. of lead. It was well known that with an ordinary straight tool—no top rake at all—a fine finish could be obtained on commercial brass without tearing. On the question of the state of the steel machined, the condition of the steel made all the difference to the finish. If the steel were left as forged, if it were annealed, if it were normalised, and if it were double normalised to remove the rather coarse crystalline structure from drop stamping—the results would be found to be entirely different. Again, the cutting angles had to be different, and the speeds had to be different. Dr. Stanton's cutting speed of only 13 ft. a minute was, of course, extraordinarily low.

Dr. Walter Rosenhain then replied to the discussion. While Mr. Taylor's criticism of the method of measuring the movement of the tool might possibly be correct, the actual facts connected with the measurement of the work by a micrometer confirmed the view that the results were not due to the digging in of the tool at all; the forces on the tool would have a tendency to work it out, not in. Dr. Stanton's friction experiments indicated that fact.

With regard to the reference to the reamered hole, metals were elastic, and in reamering the metal was stretched as well as cut; it was not unnatural that, being stretched, it should grip the thing that was stretching it. It was a remarkable thing that cast-iron did not do that, and the only explanation he could offer was that the graphite present acted as a lubricant. As to whether the cutting edge did or did not touch the work, he was rather inclined to suggest, having regard to the narrow field covered by the research, that the evidence showed that the main work of cutting was not done by the edge; that the main forces in operation were not applied to the work by the narrow strip of metal at the edge of the tool, but by the area just above it. The microphotographs were, of course, at a considerable magnification, and the point where the removed chip impinged on the bare surface of the tool might be very near the actual edge. In the case of a 10,000th of an inch cut, this was so near that it did result ultimately in the edge being broken off and rounded. Research work on the behaviour of blunt tools would be carried out later. The clearance angles actually used were mostly of the order of 10 deg.—not greatly different from the 7 deg. mentioned by Mr. Vernon. Only in one case was a clearance angle of 18 deg. used. Col. Kitson Clark had remarked that the parting of the metal from the stock was due to leverage, and this was a fair representation of what happened in some cases. It was sometimes found that some of the metal adhered to the tool—it did not follow that what adhered to the nose of the tool was the whole of the deformed zone shown in the photographs; it was probably not so. This question was one of relative cohesion; in the cases in the report it did not seize, but remained on the work. That the behaviour should be different in the case of two materials was not surprising. Further work would bring out, he hoped, information on this point. From the sections shown, it was clear that the actual particles that made up the deformed zone remained in place on the work, *i.e.*, in a constant position relative to the tool, but not attached to it.

The question of the deformed zone adhering to the steel or not was a question of lubrication, of temperature, of the character of the steel—both that which was being cut and of the tool—all being involved. Some metals would seize on each other and others would not. They had noted the difference between ordinary and lead-free brass in the paper. He doubted if it were possible, strictly speaking, to penetrate the atoms and molecules of solid matter without causing a large amount of local destruction. It was impossible to enter any solid body without crushing, splitting, and tearing it.

Dr. T. E. Stanton then replied to Mr. Taylor with regard to discontinuity when changing from one form of chip to another. Nothing of that kind had been detected. The change of force with cutting angles, both normal and tangential, gave curves which were continuous right over the range of work done. Dr. Rosenhain here stated that there was no discontinuity in changing from one to the other; the change in character was perfectly gradual. Dr. Stanton said that the definition of cutting angle they had used was that of the Manchester Association of Engineers. With regard to Nicolson's work, Fig. 37 of the report (Work done per cubic foot of metal removed) would be found, when compared with Professor Nicolson's figures expressed in horse-power per pound, to agree roughly. He believed that in the case of mild steel Professor Nicolson obtained a rough result of 2 h.p. per pound of material removed.

Mr. J. H. Hyde stated, in relation to the excessive front rake angle referred to by Mr. Vernon, that the intention in deciding on that had been to get as far away as possible from the effect of clearance, and as no question of wear of the tool arose, 10 deg. had been adopted. With regard to Mr. Robinson's question about the cutting speed of 13 ft. per minute, he would say that the relation between the vertical and horizontal forces was just the same at 80 ft. as at 13 ft. per minute, and as 13 ft. was better for the tool, that figure had been adopted.

The President then closed the proceedings with the announcement that there would be an informal meeting at 7 o'clock to-night, the subject to be discussed being "Alternatives to the 'Clash' Type of Change-speed Gears for Motor Vehicles."

On Friday, the 6th proximo, an extra general meeting would be held at 6 p.m., when a paper would be read and discussed on "Anti-friction Bearing Applications for Heavy Duty," by Mr. J. B. Dahlerus.

2-8-2 ELECTRIC LOCOMOTIVES ON THE PENNSYLVANIA RAILROAD.

THE Pennsylvania Railroad recently placed in operation three electric locomotives of somewhat exceptional interest. At the present time one part of this system is electrified on the direct-current third-rail system, while another part is on alternating current with an overhead conductor. The direct-current portion is the New York terminal section, the installation having been made a good many years ago. The voltage is 650. The Paoli suburban electrification is of later date, and is 11,000 volt, 25 cycle, single phase. This has been adopted for all future electrification work, and the direct-current section will ultimately be converted to it. Some eight years ago the Pennsylvania Railroad designed and placed in service a freight locomotive of high capacity on the single-phase service. This machine was of the split phase type, the wheel arrangement being $2 - 6 + 6 - 2$. The drive was geared and side rods were used. The machine developed 4,000 h.p. on continuous rating. The locomotive was used originally to some extent experimentally, but has been for a long while in regular service. The machine consisted of two articulated units each provided with two motors geared to a jackshaft from which side rods were driven. As the side-rod class of electric locomotive has been subject to a certain amount of criticism, and the type generally has been adjudged suitable at the best for slow freight work, it is particularly interesting that the Pennsylvania authorities should have considered this first engine so satisfactory that they have been encouraged to proceed with the design of other machines embodying a similar class of drive. These engines are all the more interesting because the one design is intended for both slow-speed freight and high-speed passenger service, by a simple alteration of the driving gear ratio.

By the courtesy of Mr. J. T. Wallis, Chief of Motive Power of the Pennsylvania Railroad System, we are now able to give particulars of these later machines. The general conditions which led up to this design, we are informed by Mr. Wallis, were as follows: An extended service test of the locomotive referred to above suggested the desirability of designing a more flexible type of alternating current locomotive for general purposes. The study of the question developed the fact that a locomotive built with single-phase commutator type motors, taking current direct from a transformer, could be designed of sufficient power, simplicity, and flexibility to be satisfactory for freight service. Further, a locomotive of this type could be built capable of developing sufficient starting tractive effort to utilise the maximum permissible axle loading for

2-8-2 ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.

CONSTRUCTED AT THE COMPANY'S ALTOONA WORKS; MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.

Fig. 36.

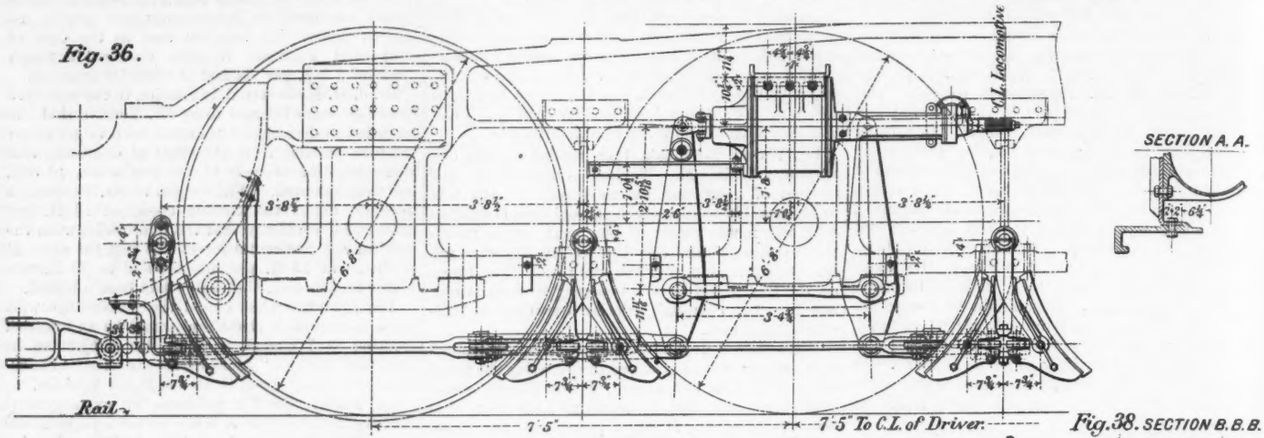


Fig. 37.

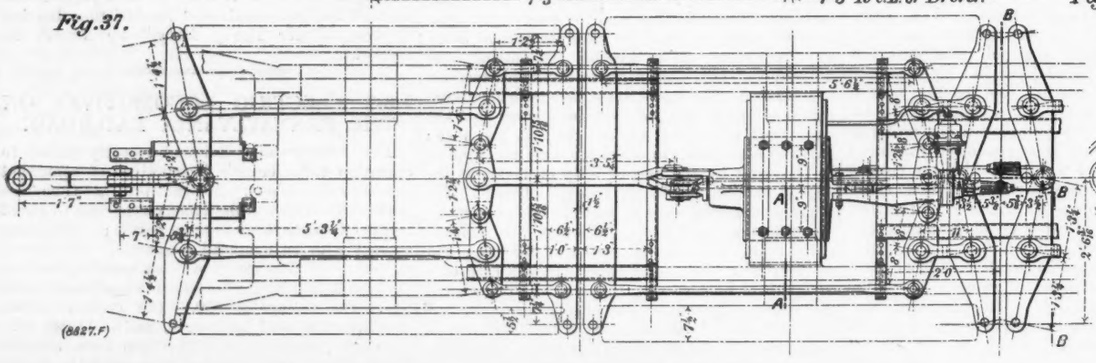
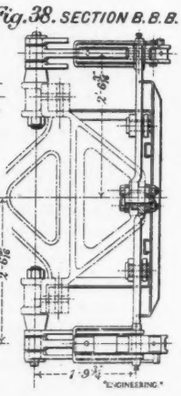


Fig. 38. SECTION B.B.B.



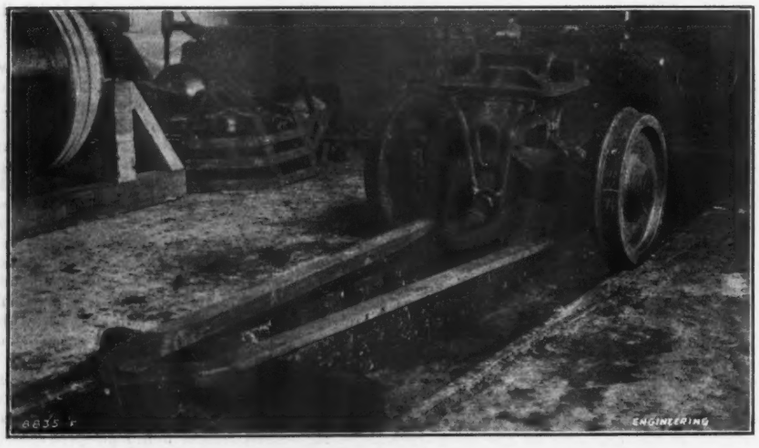


FIG. 39. TWO-WHEELED LEADING AND TRAILING TRUCK.

Fig. 40.

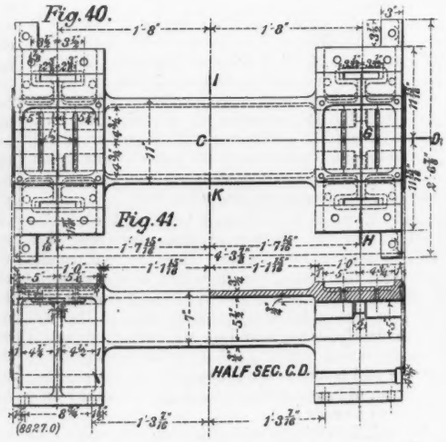


Fig. 42. SECTION G.H.

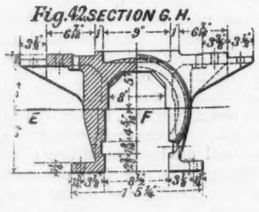
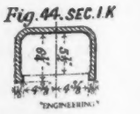


Fig. 43. SEC. E.F.

Fig. 44. SEC. I K



electric locomotives on the Pennsylvania System, of 75,000 lb. per driving axle, with a coefficient of adhesion of 33 per cent. which can be used for machines of this type. A study of the drive suggested the use of driving wheels 80 in. in diameter, with single-phase motors of the largest type available at the time, and the preliminary design evolved was for a locomotive with four pairs of drivers and four motors, developing a tractive effort at starting of 100,000 lb. and of 50,000 lb. at 23 m.p.h. or 60,000 lb. at this speed for one hour without heating. By changing the gear ratio as stated above the design became suitable for high-speed passenger service.

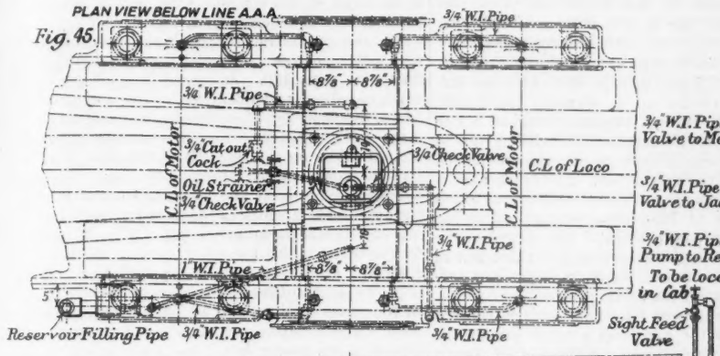
The next question to settle was that of securing the necessary tractive effort with as little unused weight as possible. The design which gave the desired results with the least possible excess weight involved placing two motors at each end of the locomotive, coupling the driving wheels in pairs by side rods, and driving each pair from one of the pairs of motors, through a gear-driven jackshaft. It also included the mounting of the whole of the control apparatus on the locomotive framing proper, and using the cab only as protection against the weather.

As stated, the design, by a change of gear ratio, was suitable either for freight or passenger service. The advantages which would accrue from having one type of locomotive to cover all classes of service except shunting were deemed sufficient to warrant the expenditure of a good deal of effort to develop a simple and rugged class of machine with suitable characteristics.

It was with this object that the three locomotives we now refer to have been constructed. They have been built and equipped at the Company's Altoona Works, the electrical equipment being supplied by the Westinghouse Electric and Manufacturing

2-8-2 ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.

CONSTRUCTED AT THE COMPANY'S ALTOONA WORKS; MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.



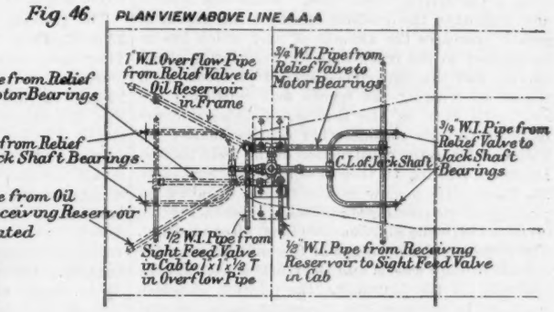
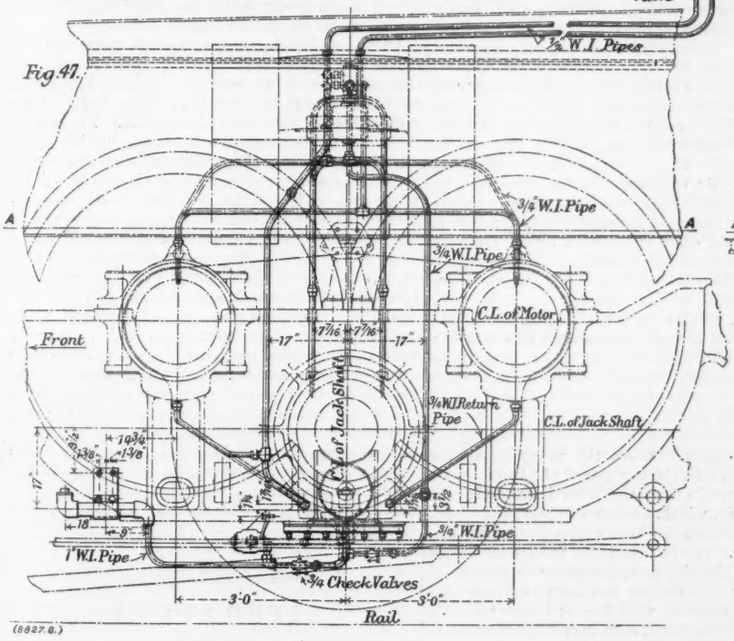
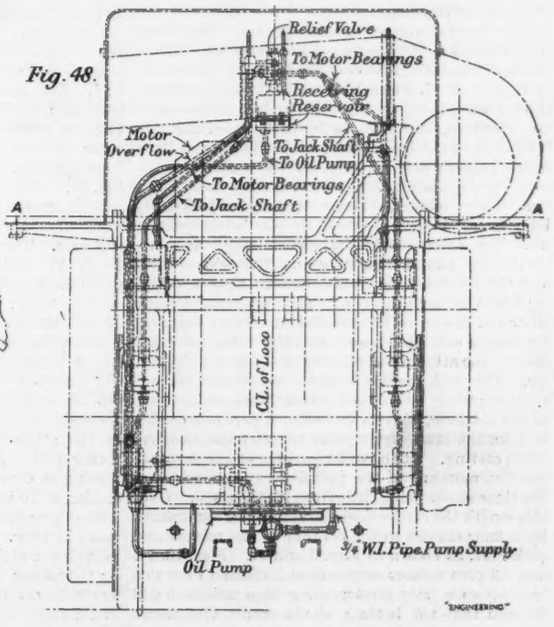
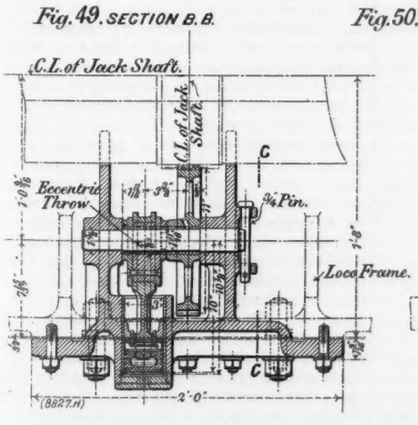
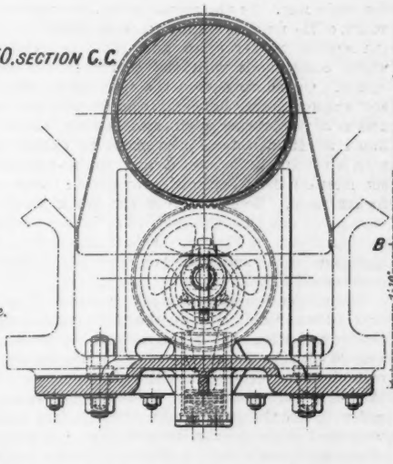


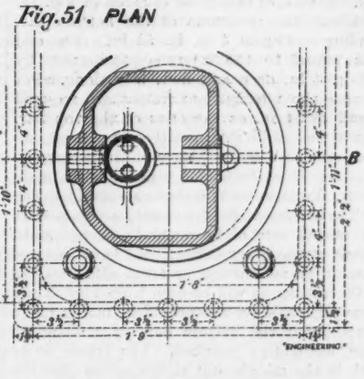
Fig. 46.
PLAN VIEW ABOVE LINE A.A.A
1" W.I. Overflow Pipe from Relief Valve to Oil Reservoir in Frame
3/4" W.I. Pipe from Relief Valve to Motor Bearings
3/4" W.I. Pipe from Relief Valve to Jack Shaft Bearings
3/4" W.I. Pipe from Relief Valve to Motor Bearings
3/4" W.I. Pipe from Relief Valve to Jack Shaft Bearings
C.L. of Jack Shaft
3/4" W.I. Pipe from Oil Pump to Receiving Reservoir
To be located in Cab
3/4" 1/2 W.I. Pipe from Sight Feed Valve in Cab to 1 x 1 x 1/2 T in Overflow Pipe
1/2" W.I. Pipe from Receiving Reservoir to Sight Feed Valve in Cab











Company of East Pittsburgh, Pa. The single-phase commutator type motors with which the locomotives are equipped will operate satisfactorily on direct current supply. The same motors are, therefore, used in all three machines, the locomotives on the direct current New York terminal section being fitted with a rheostatic control, while the alternating current machine is fitted with transformer control. The necessary details are modified to suit the third rail and overhead supply respectively. In this way a trial is being made of both the mechanical and electrical gear in both high speed passenger and heavy freight service at a minimum of expense.

We commence in this article to illustrate these locomotives by means of drawings and photographs above and on pages 126 and 138, and on Plate VII. A general elevation of the machine is given in Fig. 1, on Plate VII, while the view reproduced in Fig. 52, page 138, shows the first of the three locomotives to be completed. The completed locomotive weighs 408,000 lb. (177·7 tons), of which 307,000 lb. (137 tons) are on the driving wheels, the remainder being divided between the two trucks.

The overall length (from inside to inside of knuckles of couplers) is 68 ft. 2½ in., while the total wheelbase is 54 ft. 11 in. The rigid wheelbase, however, is only 22 ft. 3 in., and only the tyres of the leading and trailing drivers are turned with flanges. The distance of the centre of the truck wheels to the nearest drivers is no less than 16 ft. 4 in., or 73·4 per cent. of the driving wheel base. While this materially augments the guiding effect of the truck, it greatly increases the amount of play which has to be allowed to the truck axle for negotiating sharp curves, and this introduces special problems with regard to centring the trucks and equalising the load with that on the drivers. Leaving for the moment further consideration of this matter we wish to refer to the construction of the main frames. Drawings relating to these are given in Figs. 2 to 25, Plate VII, a view of the frames standing on packing in the erecting shops being given in Fig. 53, on page 138, while Fig. 54 shows them after wheeling. The large circular openings at the ends between the outside driving wheels and the truck wheels are the bearings for the jackshafts, the position of which may also be noted in Figs. 1 and 52, and in several of the detail drawings.

The frames proper consist of two large end cradles of cast steel connected by cast-steel intermediate frames. The end cradles are illustrated in Figs. 2 to 17, Plate VII, while the intermediate frames are shown in Figs. 18 to 25. Both units are standard, one end-cradle pattern serving for both ends of the locomotive, while the intermediate frame pattern does equally for the right and left sides of the machine. The end cradles each carry two main motors, motor bearings, jackshaft, bumper or buffer beam, draw-gear attachments, &c. The intermediate frames embody the horn cheeks for the driving wheels. The end cradles and the intermediate frame castings have a ruling thickness of metal of 1 in. The different sections show the design to be stiffened in various manners by flanges and ribs, bosses and lugs being provided also for the attachment of parts of the spring rigging, &c. The end cradles consist essentially of two sides tapering in to each other towards the end of the machine, where a box-shaped part is provided to take the draft rigging and to carry the bumper-beam casting. At the wider part the cradle supports the two motors and the jackshaft, the positions of the three shafts being clear from Figs. 2 and 3. Over this length the cradle sides are connected underneath by a floor curved to the contour of the motors and jackshaft, as shown in Figs. 3 and 17. Figs. 13, 14, and 15 give various sections as indicated over this length, while from the foregoing illustrations it will be seen that the bottom of the cradle also shows two shallow, longitudinal, indented ribs.

The intermediate or main frames, Fig. 19, have deep-webbed top bars and square bottom bars. The ruling thickness of the top bar, 2 ft. $0\frac{7}{16}$ in. deep, is 1 in. At the top and bottom, flanges are provided. A plan of the frame is given in Fig. 18. Fig. 20 shows the underside of the bottom bar, whose ruling section is 4 in. by 5½ in. The end cradle is joined to the intermediate frames by splices 1 ft. 4 in. deep and 2 ft. 6 in. long. For this purpose the intermediate frames are recessed to a depth of 5¾ in. at the ends of the top bar. The ends of the cradle sides, on the other hand, are furnished, as shown in Fig. 16, with deep channel-shaped pieces which fit with a taper into the main frame ends. Twenty-one 1¼ in. bolts are used for each splice. The intermediate frames only accommodate the two central sets of horn cheeks or pedestals. In the case of the outer drivers, one horn cheek is on the main frame casting and the other on the end-cradle casting, as will be seen from Figs. 3 and 19. Heavy horn stays are provided, fitting on to taper lugs under the bottom bar, as in standard American locomotive practice. The frame is so stiff both in the middle and at the splices that the horn stays can be removed without fear of the cheeks opening out.

The wheels, axles, axle-boxes, side and main rods follow standard American locomotive practice, and it is not necessary, therefore, to deal with these features. It should be noted from Figs. 3 and 19 that no wedges are employed for the driving boxes, the brakes being of the clasp type, in which shoes act on both sides of the wheels, while it is important with the design of drive adopted that the centres of the wheels should be maintained in as accurate positions as possible, without the risk of the setting being inadvertently altered by running-shed adjustments. Any wear of the bronze shoes of the pedestals is taken up in the shops. The driving boxes are of steel, fitted with bearing liners.

The two-wheeled trucks are illustrated in Figs. 32 to 35, Plate VII, and in Figs. 39 to 44, page 126. They have wheels 33 in. in diameter, with axle journals 7 in. by 12 in., lubricated with oil waste keeps. A view of the assembled truck is given in Fig. 39; this shows clearly the considerable length (10 ft. 2 in.) of the radius bar. The truck axle is carried in bearings in a transom casting, of which details are given in Figs. 40 to 44, the radius bar being attached to the bottom of the casting at the horn stays. The load is transmitted to this transom directly over the boxes, where bearings are provided on flanges on the casting for pendant spring hangers. These hangers have two bearings, centred 3½ in. apart at the top, and a single pin at the bottom, the latter carrying the ends of heavy inverted, laminated springs in front and behind the transom. These points will be clear from an inspection of Fig. 34. The hanger links have a ratio of length to spacing of the top centres of 8 : 1. The spring buckles are connected on the underside to the legs of a centre rocker casting. This is well shown in elevation in Fig. 34, in cross section in Fig. 35, and in longitudinal section in Fig. 33; it is also quite clear in the view, Fig. 39. This casting has four legs, and in the outer spaces between them the springs are accommodated, while the central space is occupied by the transom and axle. The top of this casting is finished with a 10-in. by 24-in. flat surface, from which there projects upwards a ring taking the form of a circular tooth, its diameter being 10½ in. and height 3½ in. Working in conjunction with this ring is a rocker plate, with a central tooth and a surrounding rim of tooth profile. This is shown in section in Fig. 33, while it may also be seen in Figs. 26, 27 and 32, and, in position, in Fig. 39. The load is transmitted to this casting by levers forming part of the spring gear. While the underside of the rocker plate is flat, the top side of the truck centre casting is curved off at the sides beyond the flat section of 10 in. width, as shown in Figs. 34 and 35. This design of truck has been evolved with two purposes in view. In the first place, the centre rocker provides a stabilising arrangement with a ratio of 4 : 1, tending to centralise the front end, and this works in combination with the 8 : 1 variable ratio link hangers of the truck, allowing this part sufficient lateral movement to compensate for all curves on the main line. In the second place, the swivelling action of the truck is readily accommodated between the engine rocker plate and the truck casting, which corresponds with the centre of the usual design. On sharp curves the maximum swing of the transom spring hangers, together with the gear action of the rocker plate and casting, allows as much as 10-in. lateral movement to either side, with a maximum resistance equal to one-quarter of the load on the truck, owing to the 4 : 1 constant rocker ratio. Before leaving the truck itself we may point out that the radius bar is pivoted on a casting shown in Fig. 32. This is attached to the underside of the end cradles on faces at the letter C underneath Fig. 3.

The suspension system is illustrated in Figs. 26 to 31, Plate VII. It is on the three-point system, the equalisation being interrupted as shown in Fig. 26 between two of the drivers, where the rigging of both parts terminates with helical springs. For the main part the system follows usual American practice, but the equalisation of the driver rigging with that of the trucks is uncommon. At the end of the last beam over the driving boxes are hanging stirrups, into which fit the arms of cranked levers pivotted on the main frames. The stirrup and cranked lever actually work in slots in the frames, as shown in Figs. 29 and 30. The frame slots may also be seen in Figs. 12 and 20. From the lower arm of these cranked levers rods run out towards the truck, ending by making connection with larger crank levers shown in Figs. 26, 27 and 33. The outer ends of these larger levers work on trunnions on the rocker plate. This arrangement can be seen in the three figures just referred to, while the trunnions are visible on the rocker plate in the view reproduced in Fig. 39. The two large crank levers at each end of the machine form part of one steel casting, as will be clear from Fig. 31.

We referred above to the brake gear fitted to these locomotives. This is illustrated in Figs. 36 to 38, page 126. As stated it is of the clasp type, equalised and operated by two air cylinders 18 in. diameter by 13 in. stroke, and having automatic slack adjustors. Fig. 38 is actually a vertical section taken on the line BB of the plan, Fig. 37, but is shown turned through 90 deg. The two cylinders operate on one connected set of rigging, the outer ends of which are anchored by connections, one of which is shown to the left of Figs. 36 and 37, to the truck radius bar pivot casting, as shown in Fig. 33. Compressed air is supplied by a 150 ft. capacity motor-driven compressor, delivering air to four reservoirs each of 18,300 cub. in. capacity. Two driver's valves are fitted, one in each cab. The braking power has been made equal to the actual weight on the driving wheels.

Deferring for the present details regarding the motor and jackshaft drive, we propose to conclude this article with a reference to the lubrication system provided for these three large shafts. This is illustrated in Figs. 45 to 51, page 127. The general arrangement of the piping is shown in Figs. 45 to 48, the remaining three illustrations referring to the oil pump drive. The oil pump is a reciprocating pump placed below the jackshaft in an approximately rectangular box set into a circular well in the bottom of the cradle casting, and shown in Figs. 2, 14 and 17. The pump piston is driven by an eccentric on a shaft geared by a spur wheel to the jackshaft on which teeth are cut (Figs. 49 and 50). The pump supplies oil to a reservoir under 10 lb. pressure, this being controlled by a relief valve. From this reservoir leads are run off to all bearings, a sight feed being included in the system to check correct operation. This is placed in the cab, and inserted in a loop between the pump and the receiver reservoir, operating in parallel with the supply to the bearings. The pump draws from a supply of oil stored in the bottom of the cradle frame casting. An overflow from the relief valve returns any surplus oil pumped to this storage.

(To be continued.)

LITERATURE.

Coal and Oil-Fired Boilers. By Engineer-Commander F. J. DROVER, R.N. London: Chapman and Hall, Limited. [Price 16s. net.]

IN this book the author has drawn largely upon the practice and experience of many well-known engineering and boiler-making firms, for which due acknowledgment is made, and has worked the whole together into a volume suited, in some degree, to the needs of the student entering upon a course of engineering studies. To such the book may appeal, but its value would have been enhanced had it made more appeal also to the engineer of more mature years. The latter class of reader cannot but feel that much more might have been made, for example, of the question of priming than is contained on a single page. This troublesome condition is often very persistent and always a fruitful source of inefficiency and loss, especially when associated with turbine engines and fuller treatment of it would have been welcome. Again, we think the author would have done well had he added a section dealing with the trend of modern development towards working pressures reaching up to 700 lb. or 800 lb. per square inch, for notwithstanding the rapid development and present-day popularity of the internal-combustion engine, there are few, if any, engineers, who will agree that the days of the steam engine and boiler are numbered. And it is in the direction of higher pressures, higher temperatures and the more efficient burning of the fuel and generation of the steam in the boiler that developments are looked for.

The subject, however, as dealt with by the

author in the five sections into which the book is divided, keeps the reader well inside the limits of current knowledge and practice. The book is not marked by originality, but follows usual lines, and may be fairly described as an epitome of many of the better known types of boilers and their allied auxiliary fittings commonly met with in land and marine power installations. In Part I, combustion of the fuel, superheating of the steam, air supply, feed-water control, filtering and heating, are dealt with, and are followed by a consideration of the causes and prevention of corrosion in steel boilers. Superheating, we might say in passing, is, we think, more commonly applied to marine work in this country than the author appears to believe; especially is this the case with turbine-engined vessels. In this section one is pleased to find quite the latest practice touched on in a description of the Howden Ljungström Air Preheater. Part II is given up to a consideration of various well-known types of cylindrical and water-tube boilers, and among others, in a short paragraph, the author touches upon waste-heat boilers. More consideration might have been given to this type of boiler, as although it is neither coal nor oil fired, it is closely related to the subject matter of the book, and is deserving of special attention, particularly in view of the present-day tendency to utilise the waste heat of internal-combustion engine exhaust gases for the generation of steam. This section closes with a short chapter in which the author favours the adoption of water-tube boilers of the straight tube type in the mercantile marine. In this we agree with him, but it cannot be overlooked that the principal stumbling block to the realisation of this end, in the opinion of most superintendent engineers, is the condenser question. "Give us," they say, "tight condensers and we shall have no fear of water-tube boilers."

The short opening chapter in Part III scarcely does justice, in our view, to the important subject of boiler mountings. Some useful information is given in the remainder of the section which deals with the care and management of boilers under steam, and when shut down, and outlines the procedure to be observed in their examination and testing. Part IV treats of the important subject of oil-fuel burning; enumerates some of the advantages and disadvantages thereof; describes briefly some of the oil fuel burning systems and fittings in general use to-day, and closes with a useful chapter on the management and operation of oil fired boilers in general. The concluding section deals in a summary way with such general questions as boiler design, the materials of construction and their treatment, and the methods adopted in the building of a few of the types of boilers referred to in earlier parts of the book.

The book deals almost entirely with the practice of the subject; a little more, however, of the science relating to it would have enhanced its value. In a work of this description one would expect to find some information on the question of heat transmission from the fire side to the water side of a boiler, and the relative importance of the different parts of the boiler for this purpose, but this aspect of the subject is not referred to. A diagram of average flue-gas temperatures from the furnace mouth to the base of the funnel, in a marine boiler for example, would illustrate this point to advantage. Some other matters also appeal to one as being omissions in what is otherwise a fairly comprehensive book, such, for example, as the important matter of the efficient lagging of the exposed parts of a boiler, the suitability of the lagging materials in general use, and the necessity of conserving the heat input to the boiler; the present-day developments in the use and application of powdered coal fuel burning to land and marine boilers; the application of steam blowers for tube cleaning purposes to cylindrical boilers, especially in the marine field; and one or two others. The book is well printed on good paper, the type is excellent and the illustrations clear and distinct.

Der Elektrische Zugbetrieb der Deutschen Reichsbahn. Edited by WILHELM WECHMANN. Berlin: Charlottenburg 5: R. Otto Mittelbach (Rom-Verlag). [Price 3*l.* 10*s.*]

THE German Reichsbahn, the largest railway system in existence, in the year 1922 purchased 15,000 000 tons of coal, at an expenditure of 600,000,000 gold marks, and the main reason for the consideration of electric working has been the hope of saving coal. The experience so far gained with electric railway operation has been encouraging, but reliable comparative statistics are hardly available. The development of the electric locomotive has been very rapid, and the most promising types of engines have not yet had adequate trials, while normal conditions have been unknown in Germany, more than in most other countries, during the past decade.

For this reason the last chapter of the volume before us, on electric train operation on the German State railways, is the shortest of the 12 chapters, though written by the editor of the volume, who is a high official in the Ministry of Transport. The volume is dedicated to Gustav Wittfeld, who first experimented with single-phase working near Berlin in 1903. At present electric-train operation is in use in five main districts, between Magdeburg, Halle and Leipzig, where the salt, sugar and lignite industries are centred, in Lower Silesia, in Baden, in the south and south-east of Bavaria, and near Hamburg and Berlin. What is being done on these lines and what has been learnt is ably dealt with in this quarto volume of 462 pages, which is well illustrated by 662 diagrams and a large number of plates. At Muldenstein, in the Saxon district (Halle-Leipzig), the power is obtained from lignite, in Silesia and in some other districts from coal, but in the southern districts largely from water. The Reich so far has only two large hydro-electric plants under its direct control, but big plants are approaching completion, notably on the Walchensee, where four of the units consist of spiral Francis turbines of 24,000 h.p. each and 168,000 h.p. are being installed. The main features of these plants are described in the volume which also deals with transmission lines and the interferences they may cause, with the permanent way and tracks, with the engines and their brakes, with railway shops, suburban lines, personnel, traffic statistics, and electric heating and lighting. The four repair shops in existence are being supplemented by a fifth shop of novel design at Dessau.

The editor and the many experts who have contributed the various sections presume a general knowledge of electrical engineering. Sometimes the descriptions might have been less concise and more reference letters might have been used. It is not obvious, for instance, why the kind of section switch of the horn type finally adopted makes impossible what was possible with several types first used, viz., accidental connection of two sections though on open circuit, when the two bell insulators for the contacts are simultaneously damaged. But such omissions are rare, and the description of the Lentz hydraulic reduction gear for engines fitted with single-phase induction motors is of particular interest. There is a profusion of practical detail, and theoretical considerations are only introduced where originality can be claimed in connection with design or development. The reader is not burdened with historical ballast, and what is given is up to date. The independent treatment of each section by some specialist has its drawbacks, of course, which the preparation of a good index would have diminished, but the book can thoroughly be recommended.

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. By J. W. MELLOR, D.Sc. Volume V. London: Longmans, Green & Co., 1924. [Price 63*s.* net.]

DR. MELLOR is making gallant headway in the Herculean task he has undertaken, one that might well tax the energies of a number of chemists collaborating under a general editor. Such an arrangement, however, would be more likely to occasion delay than promote speedy publication, and the rapidity with which successive volumes appear, show that this is the work of one, untramelled by coadjutors, who has devised a perfect system for extracting and digesting the contents of scientific papers in the journals of theoretical and descriptive chemistry. In three years, or less, four volumes have appeared, but the number of references to technical publications shows that the scheme must have matured long previously. The completed work which bids fair to exceed the six or seven volumes originally contemplated, will present a greater amount of detail than can be found in any similar work, while the lists of references will indicate sources of information that will be welcomed by all chemists, whether theoretical or industrial. Diligence might collect the material, but discrimination is needed in selecting and rejecting those portions that should be preserved, from those that have become obsolete or have been absorbed into more general methods. As far as we have been able to test the abundant collection, a very average perspective has been maintained, and it would not be fair to pick out some missing item in relation to a matter with which accident or circumstance has made us familiar, and hold up the hiatus as representing the character of the book. The more proper attitude is to be grateful that an invaluable compendium of information upon inorganic chemistry has been brought within reach.

The general arrangement of the book and the manner in which the references are classified have been described in the notices of earlier volumes. It will be remembered that the order in which the elements are brought under review is generally decided by the periodic law, and this plan is not without some disadvantages. But whatever method of classification had been adopted, some inconvenience would have been experienced. For example, it is unfortunate that in this volume, room is not found for the whole section on Carbon, but since the length of the articles must of necessity vary greatly, some such arrangement was necessary. On the other hand, by the plan adopted the interest is well distributed throughout. In the last volume, which included Radium, opportunity was found for well-digested articles on the several problems of radio-activity and of the architecture of the atom. In this volume, which includes the summary of the literature on cerium, the piling up of facts and references is agreeably relieved by articles on the rare earths, which offer so many puzzles that the utmost refinement of chemical analysis fails to unriddle the whole problem. The position that some of the resultant elements occupy in the periodical table is still unsettled, for no scheme has found acceptance among physicists and chemists. The engineer, however, is little interested in the subtleties involved in the arrangements of the group, or in the maintenance of the regularity and simplicity of the Mendeléeff table. He has little use for the various metals or elements, and only cerium and thorium have found application in the arts.

Carbon is on quite a different footing, and the articles on the manufacture or treatment of charcoal, graphite, carborundum and many other derivatives and associates are of special value. Here, too, is given an account of those processes which have had for their aim the synthesis of the diamond. The peculiarities of the space lattice of the diamond and of graphite are also discussed. The inclusion of such matters in one volume is not only a great convenience to the reader but indicates the close connection between different branches of physical science and the removal of separating barriers.

Gallium, indium, thallium and scandium are elements that call for little mention here, but boron and aluminium which complete the list, of elements treated in this volume, are of more commercial importance. Various processes are described for the derivation of aluminium, but the only processes, commercially successful, is that of the electrolysis of a solution of aluminium in a bath of molten fluoride. Adequate references relating to duralumin and to the zinc alloys, alzene and zalium, which may find useful application in the manufacture of scientific instruments, are given in the text.

NATIONAL ASSOCIATION OF SUPERVISING ELECTRICIANS.—The tenth annual dinner and musical evening of the above Association will take place on Saturday, February 14, at the Holborn Restaurant, London. Among those who will attend the dinner are: Sir R. Burton Chadwick, M.P., secretary to the Board of Trade; the Rt. Hon. J. R. Clynes, M.P.; Mr. A. Page, one of the Electricity Commissioners, and Vice-President of the Institution of Electrical Engineers; and Mr. J. S. Highfield; Major T. Vincent Smith; and Mr. W. E. Highfield, Vice-Presidents of the National Association of Supervising Electricians. The chairman for the evening will be Mr. F. Gill, President of the Association.

2-TON ELECTRIC LEVEL LUFFING ROOF CRANES AT BRISTOL DOCKS.

CONSTRUCTED BY MESSRS. GEORGE RUSSELL AND COMPANY, LIMITED, ENGINEERS, MOTHERWELL, SCOTLAND.

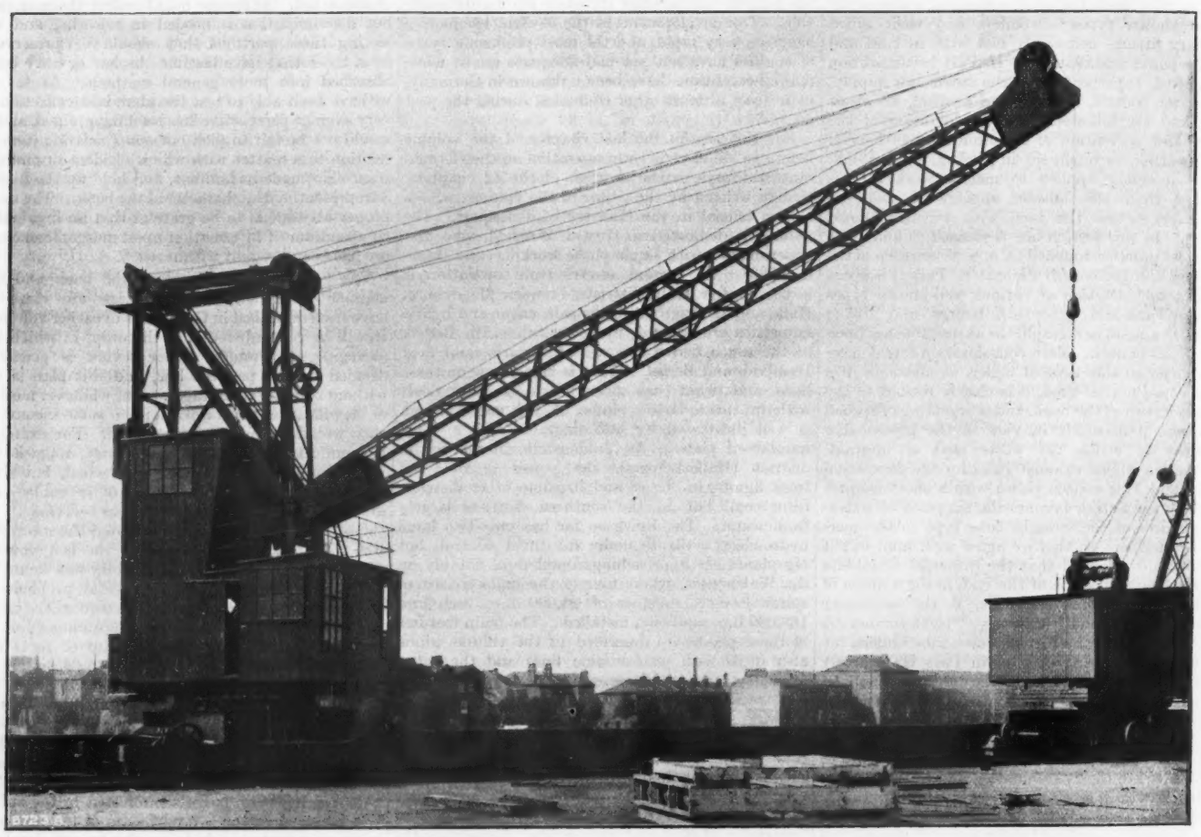
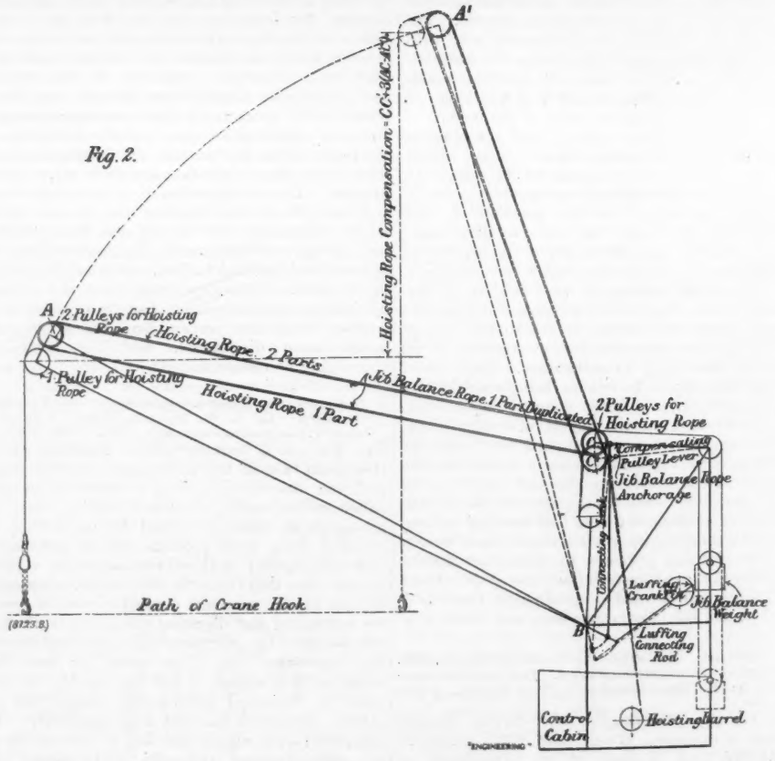


FIG. 1.

LEVEL LUFFING ROOF CRANES AT BRISTOL DOCKS.

IN Fig. 1 above, a general view is given of one of two electric level-luffing roof cranes recently installed by the Bristol Docks Committee on shed roofs at Canon's Marsh, Bristol. The cranes were built by Messrs. George Russell and Co., Limited, of Motherwell and embody a new and interesting design of level luffing gear invented by Mr. A. H. Weddell, B.Sc., one of the managing directors of the firm. We propose to describe this gear together with the mathematical principles of the motion. Since, for a proper understanding of these principles, a general idea of the construction of the cranes is necessary, we may first refer to their general arrangement.

As will be clear from Fig. 1, each crane consists of a carriage, fitted with hand-operated travelling gear at both ends, on which the rotating superstructure and jib, together with the combined machinery house and operator's cabin, is mounted, the weight being borne by a live ring of rollers. The superstructure comprises a movable portion and a rigid framework. The latter consists of two side frames constructed of steel channels, of the form shown in outline in the diagram, Fig. 2, bolted to the base which carries the hoisting and slewing machinery, and rigidly braced together. The jib is pivoted at a point above the top of the control cabin, so that an uninterrupted view is obtained from the control cabin of the work on which the crane is engaged. The movable portion is an arm hinged at one end to the top of the back of the rigid frame, the other end carrying six pulleys being pivoted to a connecting link, which in turn is pivoted to the extreme lower end of the jib. Consequently, when the jib head is raised or lowered this group of pulleys situated above the jib pivot is lowered or raised proportionately. No luffing rope is required, as the jib is luffed by means of a crank and connecting rods attached to the extension of its lower end as shown in Fig. 2. The weight of the jib is balanced by a balance weight suspended at the back of the frame. One end of each of the jib balance ropes, of which there are two, is attached to the movable arm and passes round a pulley at the jib head, then back over one of the pulleys



of the movable group at C, Fig. 2, under a fixed pulley below C, and then over a second pulley at C and a pulley at the top of the framing to the pulley on the balance weight, the end of the rope being attached to the back of the framing. The object of the fixed pulleys below C is to avoid a reverse bend in the rope.

Five pulleys are carried in the sheave at the head of the jib, one below the other four forming a guide for the hoisting rope. This disposition of the pulleys is adopted so that the lower ropes may clear the jib structure. The hoisting rope passes from the hoisting barrel to one of the pulleys at C and is then led with triple purchase to the jib-head pulley and, finally, singly to the load hook.

The mathematical principles of the luffing motion will now be described. Imagine a horizontal plane passing through point B of Fig. 2. Assume, in the first place, that the pulleys at C move in a path vertically above B, and that the hoisting rope hangs directly from the jib-head pulley A instead of being guided by the lower pulley. Let the angle which the centre line AB of the jib makes with the horizontal plane be called x. As the angle x increases the vertical height of the jib head pulley at A increases proportionally to sin x, and if the crane hook is to follow a horizontal path a length of hoisting rope must be paid out over the pulley at A equal to this increase in height. How this object is attained will be clear from what follows. Suppose the jib is at the lowest point permitted by the length of the luffing connecting-rod. The angle x will then have its smallest value, which, for simplicity, may be taken as equal to zero, and since the point C moves correspondingly with the movement of the jib, the distance BC will have a definite length. Call this distance p^1. Now when the jib is hoisted the angle x increases and the distance BC diminishes, becoming $p^1 - q^1 \sin x$, where q^1 is the length of the lower end of the jib extending past the pivot. Let the variable distance, BC $= a$, the variable distance CA $= b$ and the constant distance AB $= c$. We have seen that $a = p^1 - q^1 \sin x$, and, dividing throughout by c, we may write $a/c = p^1/c - q^1/c \sin x$. Since p^1, q^1, and c are constants, it is permissible to write $a/c = p - q \sin x$, where $p = p^1/c$ and $q = q^1/c$. Call this equation 1.

Now it is a well-known trigonometrical rule that in any triangle such as is formed by sides a, b and c

$$b^2 = a^2 + c^2 - 2\,a.c.\cos(90 \text{ deg.} - x)$$

or, dividing by c^2,

$$\frac{b^2}{c^2} = \frac{a^2}{c^2} + 1 - 2\frac{a}{c}\sin x. \quad \text{Call this equation 2.}$$

Equations 1 and 2 constitute two relations between three variables a, b and x, and by substituting in the second equation the value found for a/c in the first, a relation is found between b and x. Thus,

$$\frac{b^2}{c^2} = p^2 - 2\,p\,q\sin x + q^2\sin^2 x + 1 - 2p\sin x + 2\,q\sin^2 x$$

$$= (p^2+1) - 2\,p\,(q+1)\sin x + q\,(q+2)\sin^2 x.$$

Let p and q be so related that $p^2 = q\,(q+2)$.

Then

$$\frac{b^2}{c^2} = (q+1)^2 - 2\,(q+1)\sqrt{q\,(q+2)}\sin x + q\,(q+2)\sin^2 x$$

$$\pm\frac{b}{c} = (q+1) - \sqrt{q\,(q+2)}\sin x$$

$$= (q+1) - p\sin x \qquad \text{(Equation 3.)}$$

From this result it is apparent that when the particular relation indicated exists between p and q, the variation in the lengths of a and b, that is, in the lengths of B C and C A, are both proportional to sin x. The proportions can be so determined that if the hoisting rope is led over pulleys at C and A, either directly or with appropriate rope purchase, the length of the rope which is paid out over the pulley at A, due to the shortening of BC and CA, is exactly equal to the increase in the height of A, the jib head. Thus if, as in the present example, the hoisting rope on the cranes under discussion is led nearly vertically from the barrel to a pulley at C, and with triple purchase between C and A, we have

B C $=$ A B $(0{\cdot}317 - 0{\cdot}049\sin x)$ from equation 1

and

A C $=$ A B $(1{\cdot}049 - 0{\cdot}317\sin x)$ from equation 3,

then the length of hoisting rope paid out over the jib-head pulley as the jib rises from the horizontal position to the angle x is

A B sin x $(3 \times 0{\cdot}317 + 0{\cdot}049) =$ A B sin x.

The crane hook therefore moves in an accurately horizontal path. A little consideration will show that when the pulleys at the jib head are disposed as shown in the diagram, the accuracy is unimpaired if the line BC instead of being vertical is set back through an angle equal to that subtended at B by the distance between the jib-head pulleys. The movement of the jib balance weight is also proportional to sin x and the weight of the jib can therefore be balanced in all positions. The working load of each crane is 2 tons, and this weight can be lifted at a speed of 200 feet per minute by a motor of 35 h.p. acting through a single-reduction, double-helical, machine-cut spur gear having the pinion mounted on roller bearings and connected to the motor by a flexible coupling. A maximum working radius of 52 ft. 9 in. is possible, the minimum radius being 20 ft. The method of operation by crank and connecting rod ensures that these definite limits cannot be passed, and the speed of movement is gradually reduced to zero as the jib approaches its extreme positions. Luffing can be performed up to a speed of 120 ft. per minute. For this purpose a motor of 5 h.p. is fitted, driving the crank through totally-enclosed, machine-cut worm and double-helical spur gearing. The motor for slewing is of the same power, giving the crane a turning speed of 1 revolution in 45 secs.

Both luffing and slewing motors are of the enclosed ventilated series-wound type, and all three motors were made by Messrs. Laurence, Scott, and Co., Limited, of Norwich. The controllers used were provided by Messrs. Allen West and Co., Limited, of Brighton, and special operating gear is fitted so that the controllers can be worked from either side of the crane cabin. Potentiometer control is provided for lowering the load; that is, the field of the hoisting motor is connected in shunt across the armature through suitable resistances. The field circuit resistance is varied by moving the controller handle which engages with one of a series of notches, each giving a fixed speed for lowering a definite load on that particular notch. On test the overall efficiency of the hoisting gear, including the motor, was found to be from 74 to 75 per cent. with loads varying from half to full load, the mechanical efficiency with full load being about 84½ per cent. A noticeable feature of the cranes is their quietness in working, due to the type of gearing adopted. Both cranes were tested in all motions with a load of 3 tons.

PHYSICAL SOCIETY OF LONDON.

AT the meeting of this Society, held on December 12, 1924, at the Imperial College of Science, Mr. F. E. Smith, C.B.E., F.R.S., being in the chair, it was announced that the Council had decided to award the Duddell Memorial Medal for the year to Professor C. V. Boys, F.R.S.

A paper on "*The Sensibility of Circular Diaphragms for the Reception of Sounds in Water*" was read by Mr. J. H. Powell, M.Sc., F.Inst.P. The paper described an investigation of the sensibility of circular diaphragms as receivers of submarine sounds. The diaphragms were mounted with one face immersed in water and to the other was attached a microphonic or electro-magnetic detector. The diaphragms were all designed to have a frequency of 850 ~ under these conditions. The response of the diaphragms to sounds of a single definite frequency was measured, and resonance curves were obtained from which the magnitude of the damping due to the detector was determined. A value was also obtained for the concentration of energy in the restricted volume of the experimental tank, and an investigation was made of the effect of the proximity of sound reflectors and of the vibrating diaphragm of the source of sound. It was shown that, when corrections were made for these various effects, the values for the resonance amplitude and for the persistence of vibration were consistent with those determined mathematically by Professor H. Lamb for diaphragms under ideal conditions. The investigation was extended to cover complex sounds or "noises" of no definite pitch, and the results were again consistent with theoretical anticipations.

Dr. F. L. Hopwood said that the paper, which dealt with work carried out during the war but not previously released for publication, revived old memories, pleasant and otherwise. The author, who had worked in a tank, would have preferred the open sea, but workers in the open sea expressed a preference for tanks, while the speaker's lot had fallen to a reservoir, which combined the disadvantages of both. At the beginning of the war, the experimental diaphragms ranged from 2 in. to 2 ft. in diameter, and the available theory indicated that the amplitude under the conditions discussed would increase indefinitely with decreasing diameter. The credit for finding the real optimum diameter was due to the work of the author and Professor Lamb.

Sir Richard Paget said that some idea of the progress made could be gathered from the fact that before the war the diaphragms which were used in connection with submarine bells used to be tuned *in air* to the required pitch; the water damping would then put them out of tune by as much, possibly, as an octave. It was interesting to compare the diaphragms discussed with those found in Nature, in the ears of men and animals; the diaphragm of an ear was of much smaller diameter, and the damping was much smaller than that due to a microphonic detector. It might be interesting to experiment with an unloaded diaphragm free from damping other than radiation damping; this could be done by employing optical methods of detection. Professor Rankine and others had very successfully used the human ear as a subaqueous detector.

Captain C. W. Hume asked how far it was justifiable to express the damping due to the detector as an increment in the coefficient B in the resistance term of a differential equation for damped forced oscillations. The damping due to "loose mechanical parts" or to loose particles, to which the author had referred, would be rather in the nature of a succession of blows than a continuous function of x, and it was difficult to believe that a granule inertia microphone would offer a resistance proportional to the velocity of the diaphragm. It was noteworthy that the curve for a "simple carbon contact" seemed to resemble the theoretical curve in shape far more closely than did the other curves.

Professor A. O. Rankine said he ought to explain that the idea of using the human ear as a subaqueous detector had originated with Sir Richard Paget, who conducted his investigations while suspended in the sea by his feet. The speaker had preferred to adopt the more dignified posture normal to the human species. He did not consider the ear very sensitive to subaqueous sounds, but its damping was small in comparison with the damping due to the water.

Dr. E. H. Rayner said that the use of subaqueous bells had been mentioned. It is generally stated that the bells did not give out the notes they were supposed to give, the pitch being somewhat indefinite. How was it, therefore, that a diaphragm could be tuned to respond selectively to a given bell?

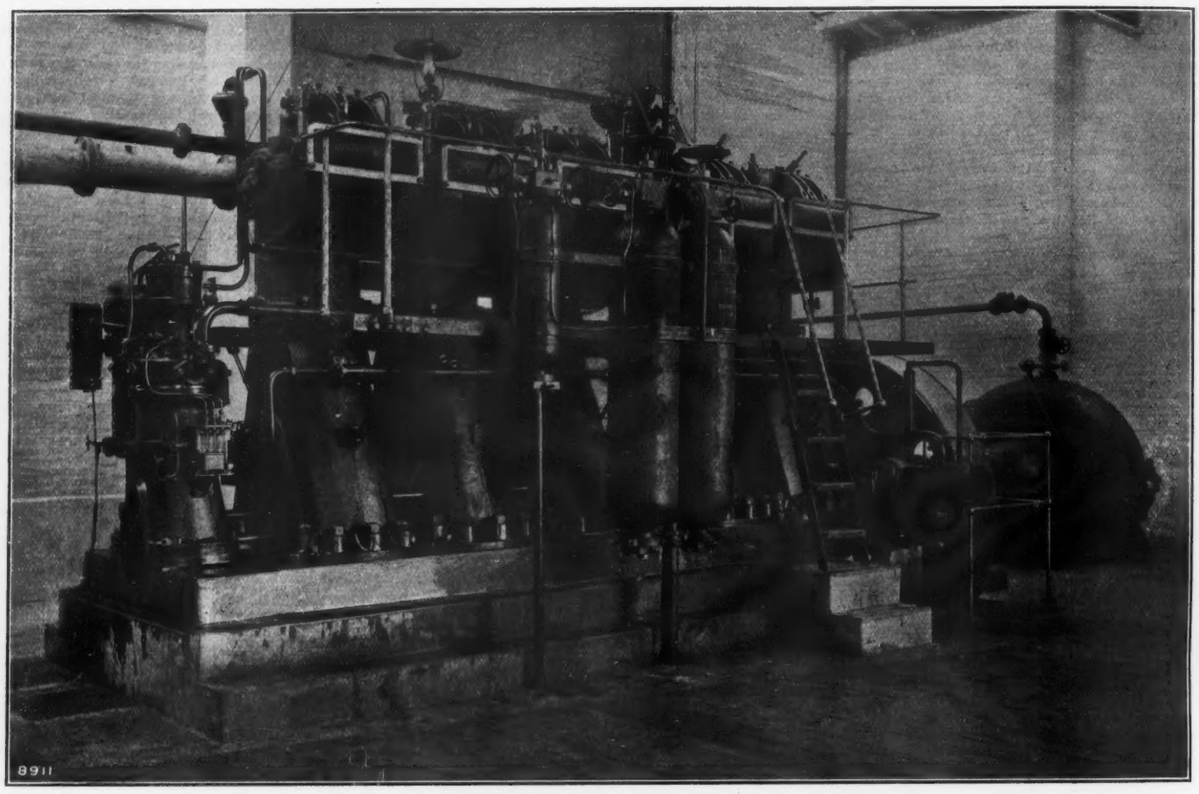
The author, in reply, said that the energy absorbed by the detector was undoubtedly used in exciting the listening telephone. The most sensitive microphone, therefore, produced the greatest damping effect. In the case of microphones, this energy merely served as a "trigger" for the release of a much greater amount of energy from a battery. In the case of the magnetophone, on the other hand, the whole of the energy was derived from the diaphragm, and for this reason the magnetophone damping was excessive, although it was a much less sensitive detector than the microphone. No attempt was made to study the case of overtones, since it was found that the frequencies of the overtones of the diaphragms examined were not in agreement with Professor Lamb's theory, probably on account of the presence of the boss and detector at the centre. In practice it was found that hydrophones with thin diaphragms, in which the overtones were excited, could not be reproduced in large numbers with any consistency, and thicker diaphragms were accordingly substituted in which the fundamental tone predominated.

An optical method similar to the one suggested had actually been used to examine the vibration of diaphragms. The work was done in 1919 by Dr. A. B. Wood, but was unpublished. His results are fully in agreement with those quoted in the paper. The microphone depended for its action on the variation in the pressure on the carbon granules, which was never zero, since there was never a complete break in the circuit; the damping was therefore continuous throughout the whole cycle. In the case of the S.C.C. microphone, when the vibration of the diaphragm became very violent, "chattering" of the contact began, but this did not occur with small amplitudes.

THE HELSBY COLLIERY LIGHTING SYSTEM.—Colliery engineers will be interested in the lighting system just placed on the market by British Insulated and Helsby Cables, Limited, of Helsby, Cheshire. Complying with the requirements of the latest Home Office regulations relating to lighting in mines, the arrangement comprises a range of flame-proof and watertight joint boxes and lanterns. The colliery joint box may be used as a terminal, straight-through, angle, three-way, or four-way box, and can, if required, be tapped to take a ¾-in. conduit. A filling plug may be inserted so that the boxes can be filled with compound. The special fittings include a bracket lantern and box for lamps up to 60-watts capacity, and a lantern with radiating "points" to take gas-filled lamps up to 100 watts capacity.

CENTRAL HOT-WATER SUPPLY.—In connection with the new houses for miners which the Denaby and Cadeby Colliery Company are having built at Conisborough, a central heating plant for the supply of hot water is to be installed. When complete the building scheme will include 800 houses, and the heating plant is designed to supply this number. Two boilers 7 ft. in diameter and 30 ft. long will be installed, together with a water tower, circulating pumps, and about 12 miles of piping. The main circulating pipes will be carried over-head, on poles, across the yards and gardens, and the supply pipes will be run through the houses under the ceilings of the ground floor rooms. The whole installation will cost approximately 14,000*l.* and the work has been undertaken by The Brightside Foundry and Engineering Company, Limited, of Sheffield.

PRICKWILLOW FEN DRAINAGE PUMPING PLANT.



PRICKWILLOW FEN DRAINAGE PLANT.

ONE of the requirements for pumping plant for fen drainage work is that, while the plant may remain idle for several months in a dry season, it must be capable of being started up at a moment's notice, at any time, in order to avoid the flooding which might otherwise follow a heavy rainfall. As a fair amount of power is needed for the work, a relatively high efficiency is called for, but careful consideration must also be given to the question of capital cost in order to keep the standing charges within practicable limits. That the Diesel engine would be particularly suitable for this class of work has been fully realised by Mr. A. Beazley, Superintendent of the Middle Fen Drainage Commission, Cambridgeshire, who installed one of the first Diesel-engine driven pumping stations for fen drainage work at the Overfall Mill in 1919. In this station, a three-cylinder Mirrlees-Diesel engine developing 150-h.p. was used to drive a centrifugal pump, and the satisfactory results achieved have led the Commissioners to install a similar, but larger, pumping unit at their station at Prickwillow, near Ely, which was formally opened on December 1 last.

The accompanying illustration has been reproduced from a photograph of the interior of the Prickwillow station, which, it may be mentioned, is the first pumping plant to be installed under the Agricultural Grants Committee. The pumping set, as shown, consists of a five-cylinder Mirrlees-Diesel engine developing 250 b.h.p. continuously at 250 r.p.m., and constructed by Messrs. Mirrlees, Bickerton and Day, Limited, Hazel-grove, near Stockport, directly coupled to a centrifugal pump made by Messrs. W. H. Allen, Sons and Co., Limited, Bedford. The plant is capable of raising 140 tons of water per minute against a normal head of 18 ft., draining in this way some 30,000 acres of land. At the head mentioned, the efficiency of the pump is 80 per cent. and the horse-power absorbed is 225 at 250 r.p.m. The head against which the pump is required to work, however, varies as the level in the drain, from which the pump draws, rises or falls relatively to that of the River Ouse, into which the water is delivered. It will thus be possible in flood time, when the lift is reduced by the rise of the water level in the drain, to handle a much larger quantity of water than that mentioned above. A 6-h.p. petrol paraffin engine, driving a single-cylinder reciprocating pump, has been provided for priming the main pump, this operation taking about 6 minutes, after which the main engine can be run up to full speed in a few seconds by compressed air stored in the two cylinders visible in the illustration. These cylinders are charged by a compressor on the engine, and as the capacity of one of them is ample for effecting a start, the other can be kept as a reserve.

We are informed that the saving in fuel cost effected by the new Diesel-engine driven plant, in comparison with the old steam-driven plant formerly employed, amounts to about 8*l.* for each working day of 24 hours, so that the economy effected in the course of a few wet seasons would be equal to the entire cost of the new installation.

LETTERS TO THE EDITOR.

THE DETERMINATION OF STRESSES BY OPTICAL METHODS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of December 5, 1924, Professor Coker has intimated that I should withdraw my earlier statements made at Toronto with reference to stress developed around a hole.

My remarks at the time of the Toronto meeting were directed to a paper of Professor Coker's which, in his absence, was presented by Mr. A. L. Kimball, Jr., and which in its presentation dealt in part with stresses and methods of analysis of stresses in gearing under dynamical forces, using optical methods. The question therefore came up if under repeated stress a nearly amorphous, isotropic, elastic substance such as celluloid could be used to predict the conditions existing in the case of steel, which is a crystalline material and which acts under static loading within its elastic range very much in the way an amorphous, isotropic material would act, but which acts under repeated loading as a crystalline material. The attitude taken by the writer was that under repeated stressing, results might not be transferred from one material having certain properties to another material having different properties. In other words, the results obtained dynamically on celluloid could not be transferred to steel with any high degree of accuracy, neither could they be transferred from one piece of steel to another piece of steel in a different state of heat treatment, or with a different composition, without expecting in some cases considerable modifications.

As a confirmation of this attitude a description of experiments performed by the writer at the University of Illinois was cited as follows: Recognising the fact that in a truly isotropic material, and within its elastic range, the maximum static stress developed at the edge of a small hole in a flat specimen is three times the average stress developed over the whole section; if this material were placed in a fatigue testing machine, and the endurance limit obtained without a hole, this endurance limit should be at least three times the value of the average stress indicated at the endurance limit obtained on the material with a small hole located in the centre of the specimen.

May I say that the endurance limit on steel is not obtained by the *fracture* of specimens after they have been overstressed as so many think, but by the specimens which are *not* overstressed and which do not break under stress repeated a large number of times. In the fatigue investigation 100,000,000 cycles have been taken as the cycle limit for wrought ferrous metals, and this seems justifiable. The stress difference between those which break and those which do not break may be made as small as the condition and grade of the material will warrant if a large number of specimens of the steel are used. Moreover the endurance limits for most wrought ferrous metals are found below the static elastic limits of the materials.

The tests referred to by the writer were performed on specimens of steel with and without holes. Several specimens of each steel were used as well as several kinds of steel and different heat treatments. In no case was the endurance limit stress developed in the specimens without holes equal to the elastic limit of the particular material considered. It is presumed that

the specimens with holes in the centre gave an endurance limit when the maximum stress at the edge of the hole reached the endurance limit of the plain specimen. In this case the average stress on the specimens with holes should, according to the theory of elasticity, be one-third of the average stress in the specimens without holes at the endurance limit. The results, however, on steel do not follow dynamically as the elastic theory dictates; neither are the results on ductile steels identical with those for brittle steels, although for any one condition of a steel the results can be repeatedly reproduced.

Recalling that the photo elastic method of stress analysis has taken over 100 years to develop, although its development has been most rapid in recent years, it would be folly for me to attempt to outline for dynamical problems the possibility of this so-called dynamical method. I am sure that Professor Coker did not intend to convey the impression that, as he calls it, this new method might be developed in a few months so that the readers of ENGINEERING might judge for themselves how far the writer's statements at Toronto were justifiable. On the other hand, may I suggest that, owing to the necessarily abbreviated summary of my statements at Toronto which appeared in ENGINEERING, Professor Coker was misled in his interpretation of my remarks?

The results of this work on specimens with holes will be published in about six months in the fourth bulletin of the Fatigue of Metals Investigation, and may be obtained free of charge by writing either to the Experiment Station or myself. It seems to me that the experimental evidence backing my remarks at Toronto has been sufficiently outlined in this letter to allow your readers to come to an intelligent understanding of what they were about. I shall be most happy, however, to correspond directly with them or through your paper, if you will permit it, should there be any further questions.

Yours very truly,

T. M'LEAN JASPER,
Asst. Professor, Engineer of Tests, Fatigue of Metals Investigation, University of Illinois.

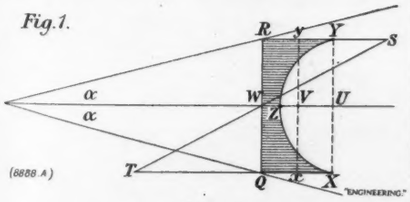
January 8, 1925.

THE DISTRIBUTION OF SHEAR IN A GIRDER.

TO THE EDITOR OF ENGINEERING.

SIR,—Regarding Professor Filon's analysis of the distribution of shear in a girder, the following graphical method of arriving at the same results as those given in your issue of December 12, page 789, was worked out at the Central Technical College just 20 years ago,

Fig. 1.



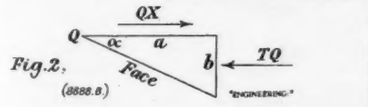
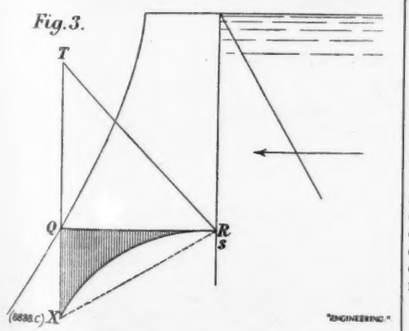


Fig. 2.

Fig. 3.



by myself, acting under instructions from the late Professor Ashcroft, whose assistant I then was:—

First determine the normal stress line T S (Fig. 1) by $f = My/I$. From Fig. 2 it will be seen that the shear stress at the face will equal $f \tan a$ because the shear must balance the normal stress and the shear stresses are equal on planes at right angles. We thus get

$$Q X \,.\, a = T Q \,.\, b$$

$$\frac{Q X}{T Q} = \frac{b}{a} = \tan a$$

This gives the two points X, Y, on the shear diagram (see Fig. 1). Next, draw in the shear line $x\,y$ corresponding to the mean shear, then the point Z is determined by the relation $Z V = \frac{1}{2} U V$, as the area of a parabola is equal to two-thirds its height multiplied by its base. Fig. 3 shows the method applied to a dam.

Yours truly,

J. M. UDALE, A.M.Inst.C.E., B.Sc.(Lond.), A.C.G.I.

893, Lothrop-avenue, Detroit, Mich., U.S.A.

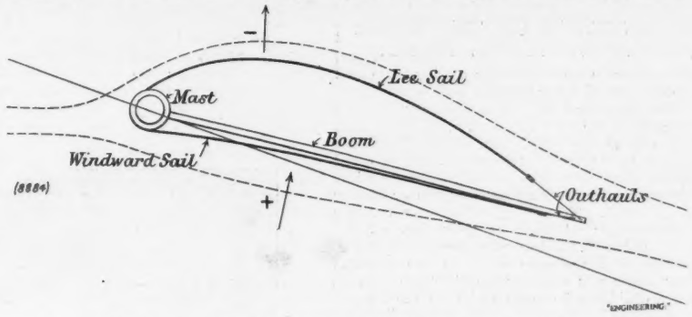
December 24, 1924.

"THE FORMATION OF WAVES."

TO THE EDITOR OF ENGINEERING.

SIR,—The phenomenon of negative air pressure to which Mr. Irminger refers in his article (page 31 *ante*) and to which the formation of waves seems likely to be attributed, is of considerable interest in connection with "fairings" for bodies exposed to the wind.

While experimenting with two-fold sails, the writer proved that when one edge of a cloth envelope is held taut in a current of air the sides are pulled out into a streamline shape. With a suitable arrangement for tightening one side of the envelope and slackening the other while "sheeting" the envelope as a sail to any angle of incidence, it was found that the negative



pressure sucked out the lee side, the resulting shape being a double-cambered one with the characteristic hump of the aeroplane wing-section.

In very light airs the lee sail "bulges" considerably even when close-hauled to small incidences.

The diagram herewith will explain the arrangement. It will be apparent that the suction will now function on the lee sail instead of losing itself in the vortex field behind the single sail.

Before Herr Flettner had his "rotors" he proved that aerofoil sails were aerodynamically better than single surfaces of canvas; but with rigid symmetrical sides he had difficulty in changing tack.

I am, sir, yours faithfully,

EWING MCGRUER, JR.

Rosneath, Dumbartonshire. January 12, 1925.

MISSING PRESSURE AND HEAT LOSS IN GAS ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—I trust you will accord me the hospitality of your columns to enable me to clear up a misunderstanding which has arisen in the discussion of Professor David's recent papers on "The Missing Pressure and Heat Loss in Gas Engines."

Amongst other matter, I referred, in connection with a criticism I made, to the radiation absorption value of Professor David's silver grid at 2,000 deg. C., and in reply he states that the rise in temperature of the grid was but 50 deg. C. The misunderstanding here is that he is considering a mean value across the grid, whereas my reference is to instantaneous temperature at the face of the grid. I thought that the context of my remarks would have made that clear. The disparity between the figures quoted above makes my criticism look absurdly lame, and it is for that reason only I have taken the liberty of writing this communication.

Yours truly,

W. J. WALKER.

University College, Dundee.

January 20, 1925.

[Dr. Walker's contribution to this discussion took the form of a communication which is reproduced on pages 813, 814 of the Proc.I.Mech.E., No. 5, 1924, recently published.—ED.E.]

THE WHITWORTH SCHOLARSHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—The correspondence which has appeared in your columns on the above subject should persuade large engineering employers, in co-operation with technical schools and universities to give facilities to their young men equal to those given in the Government dockyards. Then would Sir Joseph's wishes be carried out.

All would benefit thereby. The dockyard candidate will gain prestige more than his chance of success is diminished; some of the other candidates will secure these coveted honours, but even those who fail will gain experience and learning of great value; the employer may lose his successful candidate, but he will probably have others who will more than make good, and the tradition of his workshops will certainly be improved; some of the educational institutions may have to modify their curriculum, but compensation will be found in the results—in which they are always keenly interested.

Yours faithfully,

January 13, 1925. A. D. OTTEWELL.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondence on this subject shows that the recent awards have raised serious questions in the minds of many engineers, but is not the main point rather receding from view? Sir Joseph Whitworth created his endowment "to promote the engineering and mechanical industry of this country," and it was accepted on the condition that it should be "administered and modified from time to time, according to the progress of human knowledge in order to promote mechanical science in the highest degree." Surely, the award of eleven out of twelve Whitworth Scholarships and 46 out of 50 prizes in two years to Government apprentices is not an adequate discharge of the responsibilities of the trustee. Mr. F. G. Steed's very interesting letter explains why the selected dockyard apprentice, undergoing systematic instruction all the year round for four years under skilled teachers, is successful in this competition, but it would be difficult to devise regulations more exactly suited to the circumstances of the Dockyard apprentice. There can be no complaint against the individual dockyard apprentice who has gained a Whitworth Scholarship; no doubt he has earned it. The complaint is against the system which gives him privileges which act unfairly against the industrial apprentice.

The Board of Education fixed 21 as the maximum age of entry. What opportunity to reach the necessary standard has the ordinary youth leaving school at 15, and attending evening classes for, say, three evenings a week for half the year, even if suitable classes are available to him? On the other hand, what opportunity to secure the required practical training of at least 30 months has a youth who remains at school until over 17 and then enters a University or technical college as a full-time student? Sir Joseph Whitworth's scheme laid down 26 years as the maximum age of competitors; for a short period the age was lowered but a reversion to the higher limit was soon made, and that limit was in operation for many years. Despite this experience, a still lower maximum of 21 has been adopted by the Board of Education, although the standard of the competition is higher! It may be that under present circumstances a scholarship of 125*l.* will not greatly attract a man of 26, if the former limit were again reverted to, but the amount can be increased even if the number of awards must be diminished, and the intentions of the benefactor thus fulfilled.

Suppose that the successors in Manchester of Sir Joseph Whitworth's firm were provided with a well-equipped school within their works at the expense of the tax-payer, that it was staffed by qualified teachers also at the expense of the tax-payer, that the work of these teachers was arranged on the lines of the Whitworth Competition syllabus, the assumption

being, cramming or no cramming, that they would be judged by their successes, and that the firm in question were reimbursed at the expense of the taxpayer any loss they might otherwise entail by releasing their picked senior apprentices for systematic instruction. Is it to be imagined that under these conditions Manchester would be long without its Whitworth Scholars, or that other Manchester firms and their apprentices would fail to complain? Yet they have just the same ground for complaint against the system which thus favours the dockyards.

The time seems to have come for the consideration of the desirability of continuing the Whitworth Competition on its present lines, even without the age limit, which handicaps the industrial apprentice. Would it not be better to recognise that the general progress of engineering education since Sir Joseph Whitworth's day has increased many-fold the numbers of young engineers of the type the Whitworth scheme was designed to produce, that every public Education Authority in the country has power to grant scholarships for higher education out of public funds, and that the "promotion of engineering and mechanical industry" can now be better served by the selection of men of the standing and knowledge of the ex-Whitworth Scholar, who would devote themselves more directly to that end by research into some of the multitude of engineering problems awaiting solution?

I am, Sir, yours faithfully,

JAMES SMITH.

21, Onslow-square, Dennistoun, Glasgow.
January 19, 1925.

COALING STAITH ON THE RIVER TYNE AT WHITEHILL POINT.

THE River Tyne is frequented for coaling purposes by a large number of fishing vessels and other small craft. During the year 1924, for example, some 1,700 fishing boats took in coal there, and, in addition, 286 tugs made use of the port. The coaling facilities provided have been ultimately outgrown, and in consequence, the River Commissioners decided some time back to reconstruct in steel an existing timber staith at Whitehill Point. This work, which was carried out to the designs of their engineer, Mr. R. F. Hindmarsh, M.Inst.C.E., has now been completed, and was opened for service early in the month. The former staith was built for the old 4-ton hopper wagons, and could not be made use of by the 20-ton coal wagons now in service in the North Eastern district. As shown in the sketch-plan, Fig. 1, the new staith has a very pronounced curvature but the sharpest section is traversed only by unladen wagons. The work has been laid out so as to avoid any back traffic along the staith. The full wagons run on at the eastern end, and having discharged their loads through the coaling shoots, pass off at the western end of the staith to the main line tracks and sidings. The working of the staith is conducted almost wholly by gravity. The wagons are directed one by one along a "tip" or first-run down, which has a gradient of 1 in 23. The track then rises up a gradient of 1 in 70·7 to the coaling point, the level of which was designed to be such that on reaching this point, the wagons would come naturally to a standstill, and actual experiment proves that this aim has been satisfactorily attained under normal conditions of working. Two hydraulic capstans are provided near the coaling point, which can be used to haul up wagons which stall, either owing to adverse weather conditions or to an error of judgment on the part of the "bank rider."

The main object of these capstans, however, is to start the wagons down again after they have discharged their coal. Once started, the wagons run by gravity down a gradient which along the sharply-curved section of the staith, is 1 in 49. This relatively high gradient compensates for the sharp curvature of the track, the centre line of which has here a radius of but 131 ft. Before fixing the final plans of the new structure, experiments were made which showed that a train of the 20-ton wagons could pass round a curve of 120-ft. radius, without danger of locking buffers. The curve on the approach to the coaling point is of 600-ft. radius. The two coaling shoots are about 81 ft. apart, and coal can be delivered from them either at H.W.O.S.T. or at 10 ft. to 12 ft. above this level. The out-reach provided is 17 ft. 6 in. from the quay face.

The general character of the structure is well shown in Figs. 2 and 3. The distinguishing characteristic of it is the extensive use made of broad-flanged rolled-steel beams. For the ordinary main spans of 26 ft. 9 in. each, the beams used are 24 in. deep by 12 in. wide, and weigh 152 lb. per foot., whilst on the 46½-ft. span over the railway lines (see Fig. 2) the beams used were 40 in. deep by 12 in. wide. This span was tested by running over it a 40-ton locomotive, followed by eight 20-ton loaded coal wagons. The observed deflection was ¼ in. The beams are supported by steel trestle work, where the height above ground level is considerable, and by concrete piers elsewhere. The trestles are also constructed of broad flanged steel beams. Some of them had to be self-supporting; since the need for providing head room for the railway below, made the use of cross-bracing impossible. Elsewhere, the trestles are simple bents braced to each other along the line of the staith by mild-steel ties 2 in. in diameter.

The whole of the structure has had to be carried on made ground, and it was deemed desirable to limit the load on this to 1½ tons per square foot. To this end, concrete foundation blocks reinforced with old 35-lb. steel rails have been largely used, and a similar type of reinforcement has been employed at the top of the low concrete piers, already mentioned, to strengthen them against any spreading forces. At the actual loading point it was found necessary to support the structure on piles.

The staith is decked with 12-in. by 6-in. creosoted pitch-pine laid across the broad flange beams in 15-ft. lengths. Near the hoppers the decking has been stiffened by 24-in. by 7½-in. standard steel beams, secured under the outside edge, and a similar arrangement has been adopted at certain other points. For the track, 90-lb. flange rails have been adopted, spiked directly to the 6-in. decking.

Messrs. Clayton, Son and Co., Limited, of Leeds, were the contractors for the steel trestles and main beams; whilst the remainder of the work, including setting out, concreting, decking, railways and hoppers was carried out by the Commissioners' staff. The steel work has been protected against corrosion by coating it with "Bitumastic" enamel.

The works, it may be added, have involved also a certain amount of dredging, and the construction of a dolphin, so as to facilitate access to the staith. This can be seen in the illustration opposite.

COALING STAITH ON THE RIVER TYNE.

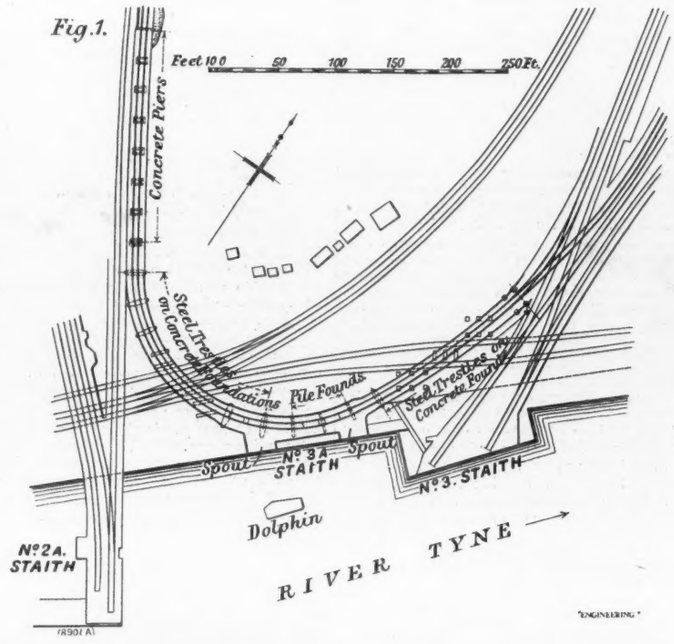


FIG. 2. 46½-FT. SPAN OVER RAILWAY LINES.

COALING STAITH ON THE RIVER TYNE AT WHITEHILL POINT.

(*For Description, see opposite Page.*)

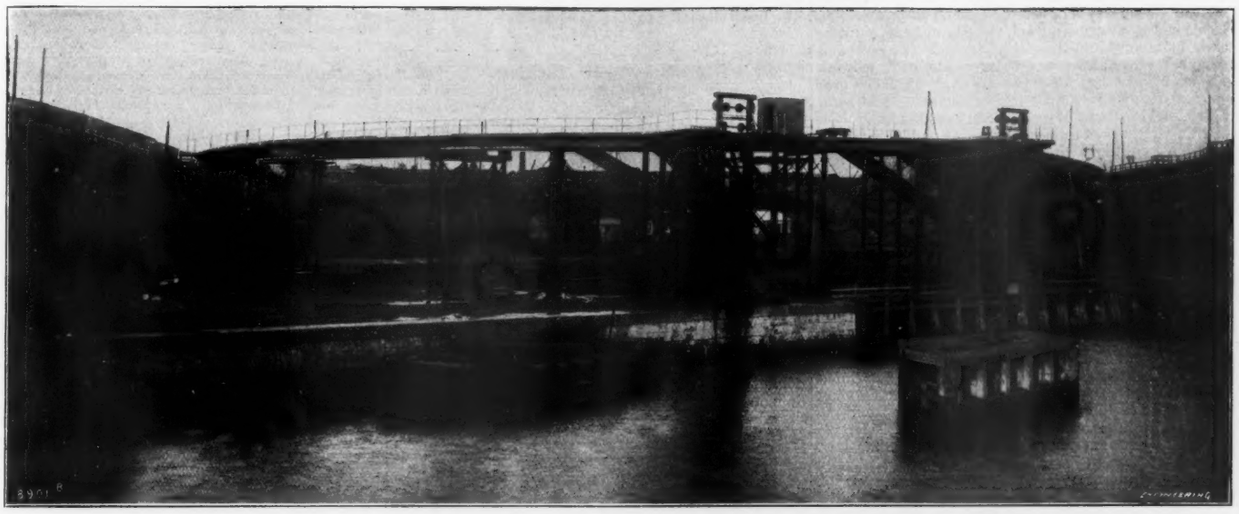


FIG. 3. GENERAL VIEW OF STAITH SHOWING SPOUTS AND DOLPHIN.

LABOUR NOTES.

WHEN the engineering trade unions decided to hold mass meetings in the districts, the object was avowed to be to stimulate the interest of the operatives in the demand for a wages advance of 20*s.* per week, which has been put forward on their behalf and is now the subject of negotiations with the Engineering and Allied Employers' National Federation. How far the gatherings have succeeded in doing so is not easy to tell. In centres where its adherents are numerous—in Glasgow, for example—the National Minority Movement was strongly in evidence, and its representatives acted pretty much as they are now generally expected to do when opportunities to discredit constitutionally-elected executive officers present themselves. Mr. Brownlie, the president of the Amalgamated Engineering Union, got a poor hearing, and the others were listened to with something resembling indifference. Up till the time of writing, similar meetings have been held at Birmingham, Wallsend, Sheffield, Manchester and Leeds.

No new argument in support of the application seems to have been put forward at any of the gatherings, and, in almost every instance, care appears to have been taken to say nothing about the figures relating to the unprofitable activity of the industry submitted at the first of the joint conferences by Sir Allan Smith. At Glasgow, it is true, Mr. Brownlie alluded to them; but he did not challenge them. He based the unions' claim on (1) the higher cost of living, (2) the low wages paid to skilled engineers, and (3) a contention that the industry was in a position to grant an advance. Of course, if Sir Allan Smith's figures are accurate—and so far nobody has seriously challenged them—the industry is not in a position to grant an advance of 20*s.* per week. That is the plainest fact of the whole matter, and, in view of it, the disinclination of the trade union representatives to go into the figures is significant. At Sheffield Mr. Bevan talked about watered capital and the obligation laid on industry by the employers to earn dividends on it. If that was intended to be a reference to Sir Allan Smith's statement it was an unhappy one, for in the figures given by the chairman of the employers' Management Committee nothing was taken for profit. The next joint conference of employers and trade union representatives for the discussion of the wages question is to take place in London on February 10.

The first of the joint conferences of employers and trade unionists to deal with the shipyard wages question is to take place in London to-day. In the forenoon the Shipbuilding Employers' Federation are to meet the Engineering and Shipbuilding Trades Federation, and in the afternoon the Boilermakers' and Iron and Steel Shipbuilders' Society. The increases claimed on behalf of the shipyard workers range from 10*s.* per week to 20*s.* per week, and are based on the increased cost of living, and the low wages paid in shipyards as compared with those paid in other industries. The employers contend that shipbuilding is a highly competitive industry, in which they have to contend with builders all over the world, and that to increase the wages further would drive more work abroad. The shipbuilding industry, they state, has already received a serious set-back as compared with the position before the advance of wages granted in June by arbitration award. According to the *London Gazette* just issued, unemployment in the industry now stands at the high figure of 31·9 per cent., and in some districts it reaches as much as 43·4 per cent., whereas at the end of May, just before the increase was given, the general percentage was 27·7 and the highest district figure was 38·8.

The National Executive of the Miners' Federation of Great Britain discussed the wages question at a meeting in London last week. Letters and resolutions dealing with the wages agreement were received from several districts, and after exhaustively discussing them the Executive decided, in view of the fact that several districts now have committees considering proposals for a new agreement, to ask all districts to forward proposals to the National Executive by February 21. On February 24, the National Executive will meet to examine the proposals and prepare a report for a national conference of delegates from the whole of the coalfields on February 26.

According to the official report of the conference, it was also decided to meet the coalowners in London on February 5. Mr. Cook added that this meeting will not be for the purpose of discussing wages or a new agreement, but only to hear the views of the owners in relation to their request for a joint committee, to go into the present condition of the industry and investigate possible remedies. The coalowners originally invited the Federation to join with them in the appointment of a Committee to inquire into the whole position of the industry, and to make recommendations to the Mining Association and the Miners' Federation.

That the negotiation of a new wage agreement for the mining industry will not be easy, is generally admitted, but a feeling prevails that the atmosphere is being needlessly charged with disturbing elements by propagandists. The statements published on January 27 by Mr. Evan Williams, president of the Mining Association, and Mr. Herbert Smith, president of the Miners' Federation, are, therefore, welcome. Mr. Williams said that he did not think that the publicity that was being given to the industrial side of the coal trade was in the best interests of those whose livelihood depended upon it, or of the community at large. In particular he deprecated statements of an alarming character, whatever the source. No greater disservice could be done to the industry, he said, than to arouse fears in the minds of the public, and especially of purchasers of coal in this country and abroad, that there was trouble brewing which would bring about a cessation or interruption of work at the mines after July. Damage had already been done, and more would follow, if consumers of coal abroad were led to believe that continuity of supply from this country was imperilled. He was sure there was more sound sanity in the main body of those engaged in the industry than they were generally given credit for, and he believed that with quiet, calm deliberation upon the realities of the position, solutions would be found for every problem that might face them. Contrary perhaps to popular belief, he could assert that there was no industry in which discussions between the two sides were conducted in better temper and spirit.

Mr. Smith said that as a month's notice was required on either side to end the present working agreement (which expires in June), no immediate dispute of a national character could take place. If the owners, or the Government, attempted to extend the present working hours, it would unite all workers more than anything. All agreed that wages were not what they ought to be, and before any crisis was talked about from either side, it was up to the workers and the owners to review the whole position, to be more open, and particularly for the owners to give all information possible as to the expenses of the industry. If it was left with the owners and men there would be a general inquiry, but the ultimate goal for the benefit of the nation and the workers was the nationalisation of the industry.

At the last moment, and not at all gracefully, the Council of the Derbyshire Miners' Association decided to withdraw the notices which had been given by its members to cease work on January 24 at the soft coal pits in the county. The decision followed upon an abortive conference between representatives of the owners and the men at Derby on the previous day, and is believed to have been largely due to disappointing response by the men to the instructions to hand in notices. The demand of the Association was for the restoration of 7½ per cent. wages reduction made in May, 1922. The owners offered to make the restoration on condition that a separate wages board was set up for the soft coal pits in the county. The men's leaders, who rejected the proposal, are, it is understood, to press the demand in other ways.

The Industrial Court has issued its award in the reference by the National Union of Railwaymen and the Southern Railway Company on the subject of the rates payable to riveters and holders-up on special work at Maidstone. According to the evidence, the men, who reside in London, were instructed by the railway company to go to Maidstone by the last train on a Saturday for work on a bridge. They arrived shortly before midnight, but the road was still required for traffic purposes and the men were not allowed to start work until 4 o'clock on Sunday morning. The question, which was raised as one of principle, was what was the proper rate to be paid to the men between the time of their arrival at Maidstone and the time of their starting on the job. The company paid time-and-a-half, but the N.U.R. claimed that the men should be paid double time on the ground

that they were ready to work, and that the time in question should be deemed to be time worked. The Court's decision is that time-and-a-half is a fair and reasonable rate in the special circumstances.

An award has also been issued in the reference relating to the wages of fitters, turners, patternmakers, blacksmiths, electrical fitters, joiners, masons, painters and plumbers in His Majesty's Dockyards and Admiralty establishments. An increase of 6s. 6d. per week was asked for on behalf of about 20,000 men employed at Devonport, Portsmouth, Chatham, Sheerness, Portland, Rosyth, Pembroke Docks, Holton Heath, Greenock, Crombie, Wrabness and Weymouth. In the award it is pointed out that "the present wages of all the principal classes of employees in the Royal Dockyards and other Admiralty establishments are the result of a series of recent decisions, in which the relative position of the various classes of workpeople, including the mechanics, has been duly taken into account. In these circumstances, and having regard to the evidence and arguments submitted, the Court are of opinion that the claim for an increase in the wages of the mechanics concerned is not one that should be conceded and decide accordingly."

A summary of several of the reports presented by representatives at the recent Russian Trades Union Congress has been prepared by the International Labour Office. It would appear, it says, from the statements of delegates that there are still considerable delays in the payment of wages in large scale industry, with the result that the situation of the workers, already difficult, becomes more acute. The delegate of the Ukrainian Section of the Metal Workers' Union stated that 60 per cent. of the workers employed in the nationalised metal-working undertakings of the Ukraine were subjected to a three and four weeks' delay in the receipt of their wages. The miners' delegate from the Donnetz Basin also complained of long delays in the payment of wages; wages for September, he said, were not paid until the beginning of November. A further grievance is that the workers receive from 60 to 100 per cent. of their wages in the form of credits for goods, opened at the consumers' co-operative societies, which are ultimately repaid by the industry. This means, as a delegate pointed out, that workers have not always the necessary ready money even to pay their trade union contributions. According to information communicated by the Commissary of Labour, the wages of metal workers in October, 1924, were 56 per cent., of textile workers 91 per cent., and of miners 52 per cent. of their pre-war wages. At the same date railwaymen's wages were 50 per cent. of pre-war wages, and those of salaried employees and Soviet officials 45 per cent.

The Ministry of Labour states that the number of persons recorded on the registers of Employment Exchanges in Great Britain on January 19, 1925, was 1,269,700—959,700 men, 39,500 boys, 234,500 women and 36,000 girls. On January 12, 1925, the total was 1,279,854, of whom 969,737 were men, 39,536 boys, 235,162 women and 35,419 girls. On January 21, 1924, it was 1,251,822, 917,792 being men, 41,011 boys, 252,721 women and 40,298 girls.

In the course of a speech delivered on Saturday last on the occasion of the launch of the S.S. Newfoundland from the Barrow-in-Furness yard of Messrs. Vickers Limited, as recorded elsewhere in this issue, Sir Frederick W. Lewis, Bart., remarked that while the shipping industry could hold its own reasonably well against foreign competition, he feared that such was not the case with the shipbuilding industry. Those owners, he added, who had postponed building in the hope of prices falling in this country now found that prices were rising, and were thus faced with a serious situation. Replying on this point, Commander C. W. Craven mentioned that 10 ships had been launched from the Barrow yard within the last 12 months, the contracts for which had been taken on at prices which did not permit of a profit. He thought, however, that the time had now come when it should be made clear that the limit had been reached in this direction. In estimating the cost of constructing ships there were many items that could not be controlled, but there were certain matters in which the community could assist the industry—one such matter being that of local taxation. At the Barrow works they were now paying 4½ times as much per man employed as they were in 1914, and he thought that something considerable could be done to reduce this burden.

In pre-war days, he added, the firm had depended largely upon the Government for work, and, in common with several others, he was hoping that something was going to develop in the way of a naval programme. No form of naval construction bore such a high percentage of wages as the construction of cruisers, and he thought that even if for strategical reasons the construction of these vessels could be postponed for a few years, it would be better for them to be put in hand now, in order to reduce the number of skilled men in receipt of the unemployment dole, by keeping them occupied in the trades for which they had been specially trained.

The prospect is that by the time this issue is in the hands of readers, the strike of engineers and other employees of the Office of Works will be at an end. All stoppages of this particular kind are unfortunate, as they cause friction where there ought really to be none. Private employers of the same classes of labour are not obliged to engage only union men, and a practice which is permissible in their case clearly ought not to be prohibited in the case of others. It is either good or bad; it cannot be good in one set of circumstances and bad in another set. It is true that, in this instance, the man objected to was not, strictly speaking, a non-unionist. He had lapsed in his membership of a union through exceeding the permissible amount of arrears of contributions, and the union was "disciplining" him for the "offence." To expect the Office of Works to assist in the disciplinary process was, however, to expect too much. Employers seek to have nothing to do with the domestic affairs of Trade Unionism, and have public opinion behind them when they strongly object to be drawn into them. The only test which they apply when engaging workers is whether the men seeking employment are technically qualified for the positions which are vacant.

BOOKS RECEIVED.

Das Materialprüfungswesen. Edited by PROFESSOR DIPL.-ING. K. MEMMLER. Stuttgart: Ferdinand Enke. [Price 23·40 marks.]

Railway Points and Crossings. By A. A. G. DOBSON. London: Crosby, Lockwood and Son. [Price 6s. net.]

The Law Relating to Building and Building Contracts. By W. T. CRESWELL. London: Sir Isaac Pitman and Sons, Limited. [Price 7s. 6d. net.]

United States Geological Survey. Mineral Resources of the United States, 1915. Part I, *Metals.* 1916, Part I, *Metals.* Part II, *Non-metals.* 1917, Part I, *Metals.* Part II, *Non-metals.* 1918, Part I, *Metals.* Part II, *Non-metals.* Washington: Government Printing Office.

Friction Clutches. By R. WARING-BROWN. London: Sir Isaac Pitman and Sons, Limited. [Price 5s. net.]

Simple Examples of Reinforced Concrete Design. By OSCAR FABER, D.Sc., M.Inst.C.E. London: Humphrey Milford. [Price 5s. net.]

Vorlesungen über Wasserkraftmaschinen. By DR.-ING. R. CAMERER. Leipzig: Wilhelm Engelmann. [Price 28 gold marks.]

The Design and Construction of Small Craft. By R. MUNRO SMITH, A.M.I.N.A. London: Association of Engineering and Shipbuilding Draughtsmen. [Price 12s. 6d.]

Annuaire de la Houille Blanche Francaise 1924–1925. Paris: Revue Generale de l'Electricité.

Concrete-making Machinery. By W. NOBLE TWELVETREES, M.I.Mech.E. London: Scott, Greenwood and Son. [Price 8s. 6d. net.]

Vues Generales sur la Théorie de la Relativité. By THOMAS GREENWOOD, M.A., Ph.D. Paris: Gauthier-Villars and Cie. [Price 10 francs.]

United States Bureau of Mines. Bulletin No. 227. *Flame Safety Lamps.* By J. W. PAUL and others. [Price 50 cents.] No. 241. *Coal Mine Fatalities in the United States,* 1923. By W. W. ADAMS. [Price 10 cents.] Technical Papers No. 296. *Size and Character of Grains of Nonmetallic Mineral Fillers.* By W. M. WEIGEL. [Price 15 cents.] Washington: Government Printing Office.

United States Geological Survey. Mineral Resources of the United States. I: 4 *Quicksilver in* 1923. By C. P. Ross. *With a Supplementary Bibliography.* By J. P. EVANS. I: 5 *Silver, Copper, Lead and Zinc in the Central States in* 1923. *Mines Report.* By J. P. DUNLOP and F. BEGEMAN. I: 7 *Tin in* 1923. By B. L. JOHNSON. Washington: Government Printing Office.

United States Geological Survey. Mineral Resources of the United States. II: 5 *Fuel Briquets in* 1923. By W. F. McKenney. II: 6 *Slate in* 1923. By G. F. LOUGHLIN and A. T. COONS. II: 7 *Gypsum in* 1923. By K. W. COTTRELL. II: 8 *Peat in* 1923. By K. W. COTTRELL. II: 11 *Carbon Black Produced from Natural Gas in* 1923. By G. B. RICHARDSON. Washington: Government Printing Office.

THE INSTITUTION OF GAS ENGINEERS.—The Institution of Electrical Engineers has had presented to them by the Institution of Gas Engineers an engraved plate for the production of a Presidential certificate. The first impression from this was handed over by the President of the Gas Engineers, Mr. J. Ferguson Bell, M.Inst.C.E., Chief Engineer to the Derby Gas Light and Coke Company, at a recent meeting of the Electrical Engineers which was presided over by Mr. W. B. Woodhouse. The recipient was Dr. Alexander Russell, M.A., D.Sc., LL.D., F.R.S., President of the Institution for 1923–24.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Visits paid to representative iron and steel works in this district leave the impression that though quiet optimism is the prevailing keynote, the actual rate of progress towards improved conditions is very slow. A striking feature is the dissimilar state of order books at comparable concerns producing the same class of goods. In many instances there are scarcely sufficient orders to guarantee even part-time working for a month ahead. On the other hand, the more favourably situated businesses are not only engaged at something approaching full capacity, but are already suffering from lack of highly skilled labour. Sheffield Chamber of Commerce Journal, issued yesterday, reports good prospects of growing demands for shipbuilding and general engineering materials, for house ironwork, colliery equipment, railway wagon and carriage frames, axles and tyres, springs, and miscellaneous castings. The miscellaneous tool trades, says the same authority, appear to have better prospects, for the railway and electrical industries look like expanding, though there is the strike danger to keep in mind. Heavy steel is still patchy, with business on export account exceptionally difficult to obtain in face of the lower rates quoted by Continental competitors. There is a considerable proportion of plant unemployed. Mining and electrical enterprise accounts for a welcome demand for special plant. Business in high-grade steels suffers acutely from the restricting effects of foreign tariffs. The anxiety felt by makers of special tools and high-class steels at the enormous increases proposed in the new French Customs Bill is reflected in the fact that customers are being circularised with the object of swelling opposition to that measure. Business in saws is easier after a brisk run, but there are indications of improved bookings in files and drills. Farm and garden tools are more freely on order than a year ago, despite the fact that allotment gardening has been restricted by building enterprise.

South Yorkshire Coal Trade.—The recent improvement has not been maintained, and in consequence some collieries may find it necessary to restrict output. Best steams are in strong demand for home consumption, but the tonnages going away for shipment display no signs of expansion. Cobbles and nuts have fallen off somewhat and bunkering requirements are on the quiet side. Slacks are gradually improving, though inferior sorts do not find a ready market. House coal is distinctly dull, demand being far below the seasonal level. Foundry and furnace coke have received a set-back, though an early improvement is expected. Quotations:—Best branch handpicked, 30s. to 33s.; Barnsley best silkstone, 26s. to 28s.; Derbyshire best brights, 26s. to 31s.; Derbyshire best house, 24s. to 26s.; Derbyshire best large nuts, 22s. 6d. to 25s. Derbyshire best small nuts, 14s. to 16s.; Yorkshire hards, 19s. 6d. to 23s.; Derbyshire hards, 19s. 6d. to 22s.; rough slacks, 9s. 6d. to 12s.; nutty slacks, 8s. 6d. to 10s. 6d.; smalls, 4s. to 6s. 6d.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though the statistical situation of Cleveland pig iron is healthy, makers' stocks being well oversold, values are steadily falling. Home consumers are still in the market, and are making contracts from time to time, but naturally they act with caution in face of the falling movement. Home needs are expected to expand sufficiently to absorb recently increased output, but the continued absence of Continental demand is much to be regretted. Foreign firms are still well underselling the products of this district in markets abroad. No. 1 Cleveland pig is now 84s.; No. 3 g.m.b. is on sale at 79s.; No. 4 foundry is put at 78s.; and No. 4 forge is quoted 77s.

Hematite.—East Coast hematite makers continue to take a firm stand, though they are still handicapped by very considerable unsold stocks. In this branch also, sales to the Continent are hardly heard of, but local needs are fairly good, and Sheffield consumers continue to buy a few parcels; whilst hope is entertained that America may purchase fair quantities. No. 1 is 87s.; and mixed numbers are 86s. 6d.

Foreign Ore.—Imported ore is little inquired for and transactions are hardly heard of, but sellers still base market rates on best rubio at 22s. 6d. c.i.f. Tees. Contracts could doubtless, however, be made on lower terms.

Blastfurnace Coke.—Local consumers of Durham blastfurnace coke continue to buy fair parcels. The supply is plentiful, and good average qualities are obtainable at round about 24s., delivered to users in this district.

Manufactured Iron and Steel.—There is continued considerable Continental competition in several branches of manufactured iron and steel, but price cutting by firms abroad is said to be less keen than it has been. A few parcels of German plates are reported to have been purchased by North East Coast shipbuilders. Among the principal market quotations for the production of this district are: Common iron bars, 12l.; iron rivets 14l. 5s.; packing (parallel), 8l.; packing (tapered), 11l. 10s.; steel billets (soft), 8l. 10s.; steel billets (medium) 9l.; steel billets (hard), 9l. 10s.; steel boiler plates, 13l.; steel ship, bridge and tank plates, 9l. 15s.; steel angles, 9l. 10s.; steel joists, 9l. 10s.; heavy sections of steel rails, 9l.; fish plates, 12l.; and sheets, No. 24 gauge (black), 12l.; while galvanised corrugated are quoted at 17l. 10s.

NOTES FROM THE NORTH.

GLASGOW, WEDNESDAY.

Scottish Steel Trade.—It cannot be said that the Scottish steel trade is recovering any of its lost ground and the process of improvement seems still to be afar off. Producers are hopeful, however, that a gradual change for the better will come along soon, and that ere many months are past active conditions will be general, and there are even some who say that they can see signs of a change. For the present, with which we are chiefly concerned, there is little fresh to report as new business is still exceedingly scarce and employment is suffering accordingly. The shipbuilding industry is not taking up much local material and general buying is very poor also, with the result that production is much below the full capacity of the plants. Inquiries there are in the market, but in few cases do they amount to anything approaching a decent tonnage. The brightest spot in the industry continues to be light sheets, for which there is still a good demand both on home and export account. Bookings amount to a considerable tonnage and in most works active conditions are assured for some months to come. The inquiry at the moment is not just so heavy as it was and buyers have perhaps covered their more immediate forward requirements, but there are some indications that fair quantities have still to be fixed up. In the heavier gauges there is not so much doing but some makers have quite a good tonnage booked. Prices all round show no change.

Malleable Iron Trade.—In the West of Scotland malleable-iron trade the conditions have not changed and business is very stiff. Some establishments have a fair amount of work on hand, but the majority are rather badly off for immediate orders. Prices are steady with "Crown" bars called 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—There has been little change in the state of the pig-iron trade of Scotland and although there has been a little better demand of late, stocks on hand are still large. Foundry iron consumers have been buying rather more freely, but a considerable improvement will be necessary before any material change in conditions is noticeable. Hematite iron is slow of sale as the steelmakers are quiet and the price is unchanged at 4*l.* 15*s.* per ton, delivered at the steel works. Foundry iron for the home trade is unaltered from last week at 4*l.* 12*s.* 6*d.* per ton for No. 1, and 4*l.* 10*s.* per ton for No. 3, both on trucks at makers' yards.

Shipments of Scottish Pig-Iron.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, January 24, was very similar to that of a year ago and amounted to 693 tons. Of the total 521 tons went overseas and 172 tons coastwise. For the corresponding week of last year the figures were 651 tons to foreign destinations and 33 tons coastwise, making a total shipment of 684 tons, or 9 tons less than during last week.

Wages in the Manufactured Iron Trade Reduced.—The following intimation has been made to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, by Sir John M. MacLeod, C.A., Glasgow:—"In terms of the remit I have examined the employers' books for November and December, 1924, and certify that the average net selling price brought out is 12*l.* 5*s.* 9·07*d.*" This means that there will be a decrease of 2¼ per cent. in the wages of the workmen.

Wages in the Scottish Pig-Iron Trade Reduced.—Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Board of Conciliation for the Regulation of the Wages in the Pig-Iron Trade of Scotland, have received intimation from Messrs. Kerr, MacLeod and Macfarlan, C.A., Glasgow, that their examination of the employers' books for October, November and December, 1924, shows that the average net selling price for these months was 4*l.* 12*s.* 11*d.* per ton. This means that there will be a reduction in the wages of the workmen of 4 per cent. on basis rates.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION—ERRATUM.—We regret that, in our comments upon the exhibits (see page 82 of our issue of January 16), we did not keep two distinct firms apart. Messrs. W. Watson and Sons, Limited, of 313, High Holborn, point out to us that they were the exhibitors of the selenium density meter intended for general photometric work (and not for X-ray photometry, as we stated) in addition to photographic dry plates, of which they made a special show at the Exhibition. The X-ray apparatus and the Hall tungsten lamp, which we described, were the exhibits of Messrs. Watson and Sons (Electro-Medical), Limited, of Sunic House, 43, Parker-street, Kingsway. We regret that this mistake was through the similarity of the names.

CONTRACTS.—The Vickers Spearing Boiler Company, Limited, of 20, Kingsway, London, W.C.2, have recently been successful in securing an order from the West Midland Sugar Company, Limited, as a sub-contract from Messrs. Duncan Stewart, Limited, of Glasgow, for the supply of four cross-type water-tube boilers fitted with "Illinois" chain-grate stokers. The equipment is for service at the new sugar beet factory at Kidderminster.—Messrs. Joseph Kaye and Sons, Limited, of Lock Works, Leeds, have received large orders for the supply of seamless steel oil feeders from the London and North Eastern Railway Company.—Messrs. Frank How and Co., manufacturers of the "Trojan" brand of lubricating oils, have secured a contract from the Air Ministry for the supply of aero-engine oil.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 7 p.m., at Storeys-gate, S.W.1. Informal meeting. Discussion on "Alternatives to the 'Clash' Type of Change-speed Gear for Motor Vehicles." Friday, February 6, at 6 p.m. Extra General Meeting. "Anti-friction Bearing Applications for Heavy Duty," by Mr. J. B. Dahlerus.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "Notes on High-voltage Electrical Transmission," by Mr. E. Ambrose. Friday, February 6, at 7.30 p.m. Lecturette, "The Measurement of Hardness and Allied Properties of Metals," by Mr. Edward G. Herbert.

THE WEST YORKSHIRE METALLURGICAL SOCIETY.—Saturday, January 31, at 6.30 p.m., at the Bradford Technical College. Conjoint meeting with the Institute of British Foundrymen, West Riding Branch. Paper on "Scrap Metals," by Mr. G. Ledgard.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, February 2, at 5.30 p.m., at the Geological Society, Burlington House, W.1. Presidential address by Mr. A. Stewart Buckle, M.Inst.C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, February 2, at 7 p.m., at Victoria-embankment, W.C.2. Additional Informal Meeting. Further discussion on the I.E.E. Wiring Regulations. Wednesday, February 4, at 6 p.m. Wireless Section Meeting. "The Optimum Damping in the Auditive Reception of Wireless Telegraph Signals," by Mr. L. B. Turner, and Mr. F. B. Best. Thursday, February 5, at 6 p.m. Ordinary Meeting. Sixteenth Kelvin Lecture. "Electrical Forces and Quanta," by Mr. J. H. Jeans, M.A., D.Sc.

THE BRADFORD ENGINEERING SOCIETY.—Monday, February 2, at 7.30 p.m. At the Bradford Technical College, Great Horton-road, Bradford. Lecture, "The Ultimate Position of the Single-phase Motor in Electric Power Distribution," by Mr. W. A. Benger.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-WEST SECTION.—Monday, February 2, at 7.30 p.m., at the Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester. Lecture, "The Design and Construction of a Piano Player," by Mr. G. B. Walker.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, February 2, at 7.30 p.m., in the Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne. "Subsidence Due to Coal Workings: its Effect on the Surface and on Structures," by Mr. W. C. Knill, B.Sc.

THE ROYAL SOCIETY OF ARTS.—Monday, February 2, at 8 p.m., at John-street, Adelphi, W.C.2. Cantor Lectures, "Radiological Research: a History" (Lecture III), by Mr. V. E. Pullen. Wednesday, February 4, at 4 p.m. Truman Wood Lecture, "The Stability of Atoms," by Sir Ernest Rutherford, M.A., D.Sc. Friday, February 6, at 4.30 p.m. Indian Section. "Population Problems from the Indian Census," by Mr. J. T. Marten, will be read by Mr. H. R. Crosthwaite.

THE INSTITUTION OF THE RUBBER INDUSTRY.—Monday, February 2, at 8 p.m., at the Engineers' Club, Coventry-street, W.1. "The Calendar in the Rubber Industry," by Mr. W. G. Martin, F.I.C.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, February 3, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "Decomposition of Paraffin Wax at 450 deg. C. in Presence and in Absence of Hydrogen under High Pressure," by Mr. H. J. Waterman, Ph.D., and Mr. J. N. J. Perquin.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 3, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Papers to be submitted for further discussion: "The Southampton Floating Dock," by Mr. Ernest Hinkly Salmon, D.Sc., M.Inst.C.E. "Southampton Floating Dock: Subsidiary Works," by Mr. Francis Ernest Wentworth Shields.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, February 3, at 6.30 p.m., at 85–88, The Minories, Tower-hill, E.1. "The Treatment of Boiler-feed Water," by Mr. W. B. Lewis and Mr. G. S. Irving.

THE MANCHESTER METALLURGICAL SOCIETY.—Tuesday, February 3, at 7 p.m., at the College of Technology, Manchester. "Corrosion and its Prevention," by Mr. S. F. Barclay, Ph.D., B.Sc.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, February 3, at 7 p.m., at the Chamber of Commerce, New-street, Birmingham. Discussion on "Metal Melting."

THE INSTITUTION OF AUTOMOBILE ENGINEERS: COVENTRY CENTRE.—Tuesday, February 3, at 7.25 p.m., at the Broadgate Café, Coventry. "Some Notes on British Methods of Continuous Production," by Mr. F. G. Woollard.

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, February 3, at 7.30 p.m., at Armstrong College, Newcastle-on-Tyne. Open discussion.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, February 4, at 8 p.m., at the Society's Rooms, The Temple, Dale-street, Liverpool. "Notes on the Longitudinal Strength of Ships," by Mr. E. F. Spanner, M.Inst.N.A.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Thursday, February 5, at 5.15 p.m., at Albemarle-street, W.1. Afternoon Lecture. Sir William Bragg on "The Properties and Structure of Quartz" (Lecture II).

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, February 5, at 5.30 p.m., at 7, Albemarle-street, W.1. Lecture, "The Operation of Flying Boats in the Mediterranean," by Air Commodore C. R. Samson.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, February 6, at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1. "Flying in Australia," by Mr. H. L. J. Hinkler.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, February 7, at 4 p.m., at the Grand Hotel, Aytoun-street, Manchester. Lecture, "A Psychological Examination of Foundry Life," by Mr. V. C. Faulkner. At 6.30 p.m., Annual Dinner.

THE HULL ASSOCIATION OF ENGINEERS.—Saturday, February 7, at 7.15 p.m., at the Municipal Technical College, Park-street, Hull. Lecture, "Recent Developments in Marine Auxiliaries," by Mr. J. Sim, B.Sc.

THE SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE.—Saturday, February 7, at 7.30 p.m., at the Royal Technical College, George-street, Glasgow. "Steam Condensing Plants," by Mr. D. L. Hall.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—A serious warning was sounded to the Welsh coal trade on Monday last when Mr. C. L. Clay, presiding at a meeting of the Cardiff Chamber of Commerce, mentioned that the year 1924 had shown a great falling off in coal exports as compared with 1923, and that he was afraid that 1925 was likely to prove still worse. He had just returned from France, a country which had been their best customer for a large variety of coals, and had learned that Welsh coal was hopelessly too dear. Wales was consequently shut out, first by the increased and increasing output of the French collieries which was inevitable; secondly, by German reparation coal, which was equally unavoidable; and, thirdly, by German free coals, which were sold very much below Welsh prices. Then, again, there was the Belgian, Dutch and American coal to compete with, and even if Frenchmen wished to buy British coal they were tempted to buy D.C.B. from the North-East Coast, which was obtainable at a lower price than anything South Wales could offer. The prospect seemed to be very bad, unless they could reduce the c.i.f. price, and that could only be attained by the assistance of the Great Western Railway Company and all sections of labour concerned. It was not fair to ask one section of labour alone to sacrifice its leisure and its earnings for the benefit of the community, but if all sections were approached simultaneously something might be done. In any case, if labour, by increasing the opportunities for trade, suffered perhaps a decrease in its nominal earnings, the result of larger outputs and more trade would be that the cost of living would go down to such an extent that they would not be very much, if any, worse off. On the other hand, if labour was going to insist on its leisure and nominal earnings and so strangle the export trade, the cost of living was bound to go up. Meanwhile, business on the coal market comes in slowly, and both buyers and sellers are adopting a hand-to-mouth policy. Prices are irregular, and while some collieries are fairly well placed for the present and able to maintain values, the majority are in need of fresh business, and to buyers able to give quick despatch will grant small concessions and then await developments. The volume of shipments, nevertheless, is fairly substantial, exports as cargo from South Wales last week amounting to over 550,000 tons, compared with 508,000 tons in the previous week. Of late, shipping has not come to hand so well, and it is probable that shipments will show a reaction in the coming week. Best Admiralty large coals rule from 26*s.* 6*d.* to 27*s.*, with seconds relatively strong at 25*s.* 6*d.* to 26*s.* 3*d.* Drys, however, are plentiful and weak at 24*s.* 6*d.* to 26*s.* 6*d.*, with Monmouthshires irregular from 23*s.* to 25*s.* Best bunker smalls are round about 16*s.*, while cargo smalls range from 13*s.* to 15*s.*

Iron and Steel.—Exports of iron and steel goods last weeks totalled 19,885 tons, compared with 24,946 tons in the previous week. Shipments of tinplates and ternplates amounted to 6,430 tons, against 12,513 tons, blackplates and sheets to 3,364 tons against 5,730 tons, galvanised sheets to 4,083 tons against 4,445 tons, and other iron and steel goods to 5,706 tons against 2,457 tons. The decision of the Conference shipping lines to abolish the surcharge of 5*s.* per ton on general goods shipped to the Far East from South Wales will, it is hoped, lead to an improvement in the volume of the direct trade with those countries. The new rates come into operation on February 1.

BRITISH PORTLAND CEMENT ASSOCIATION.—The use of reinforced concrete as a means of building, promises to receive considerable stimulus and practical support from the British Portland Cement Association, the formation of which has been officially announced. The offices of the organisation are situated at 20, Dartmouth-street, Westminster, London, S.W. 1, where free advice and assistance will be provided for architects, builders, public authorities and others interested in this type of construction. In addition to placing at the disposal of such inquirers the services of the Concrete Utilities Bureau which has been merged into the association, a number of travelling experts have been appointed. These authorities will visit any locality for the purpose of giving help and advice on matters connected with concrete construction. The director of the association is Brig.-Gen. A. C. Critchley.

2-8-2 ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.

CONSTRUCTED AT THE COMPANY'S ALTOONA WORKS; MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.

(*For Description, see Page* 125.)

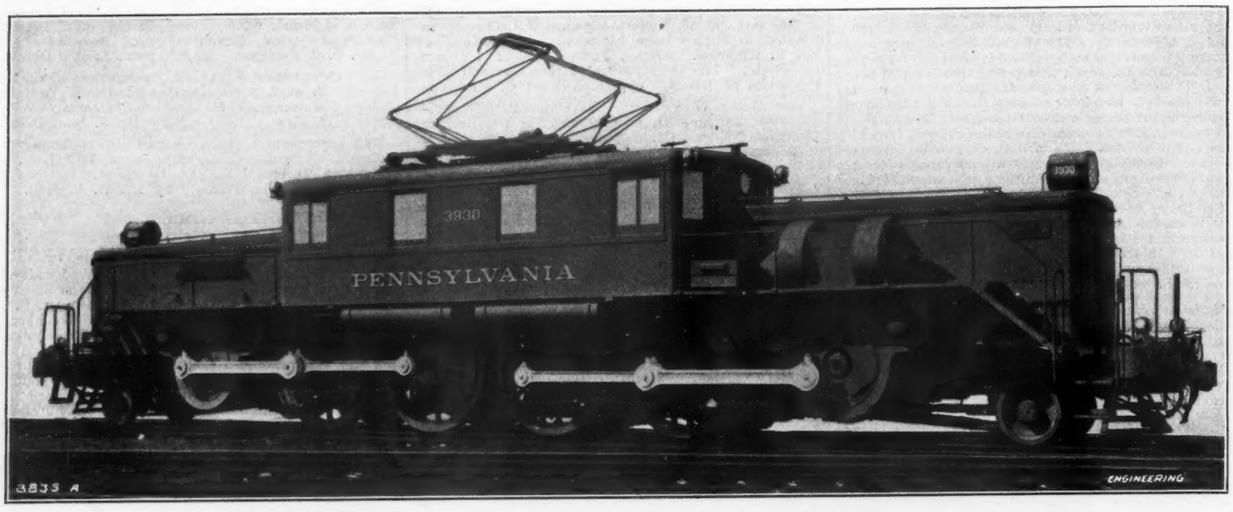


FIG. 52. GENERAL VIEW OF SINGLE-PHASE EXPRESS PASSENGER TYPE.

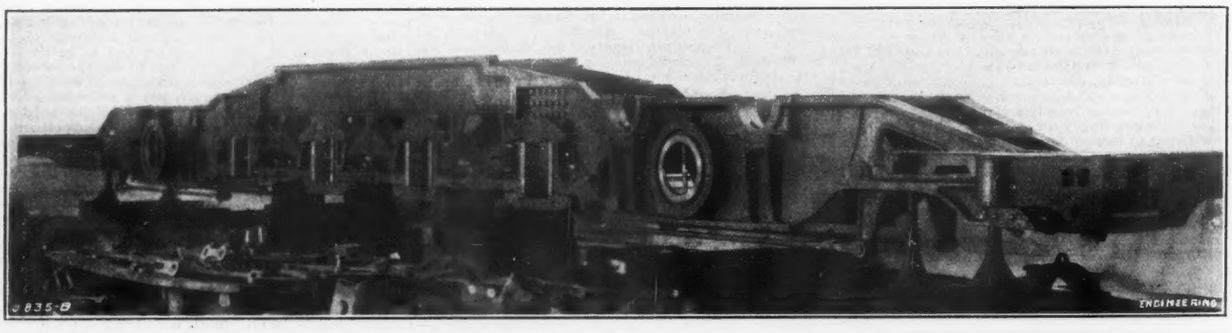


FIG. 53. LOCOMOTIVE FRAME WITH SPRING RIGGING IN PLACE.

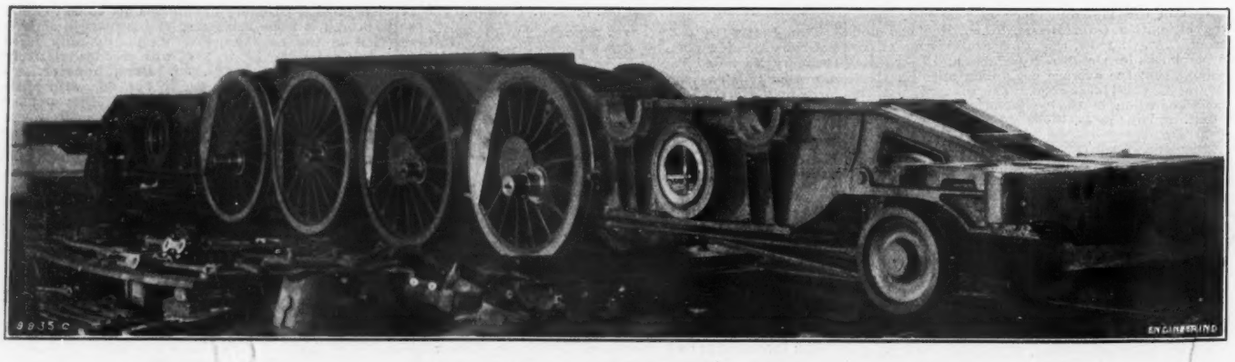


FIG. 54. LOCOMOTIVE FRAME, AFTER WHEELING.

THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.—In connection with the recent celebration of the bicentenary of Sir Christopher Wren, the Royal Institute of British Architects published a book on "Wren and His Work," including St. Paul's Cathedral, written by contributors who were each intimately acquainted with the aspect with which they dealt. As the profits of the sale are devoted to the St. Paul's Preservation Fund, a way to help would be to obtain this attractive and well-illustrated record, of which the title is "Sir Christopher Wren Memorial Volume, 1723-1923." The sale of only one thousand copies of the five-guineas edition would enable the R.I.B.A. to hand over a sum of 2,000 guineas to the fund. Each purchaser would be acknowledged in *The Times* list as a subscriber of two guineas. The price is 5*l.* 5*s.*, and orders, enclosing remittance, should be sent to The Librarian, R.I.B.A., 9, Conduit-street, London, W.1.

UNDERGROUND RAILWAY EXTENSIONS.—Tenders amounting in all to 231,000*l.* have now been accepted by the Underground Company for the sub-surface portions of the four stations on the Clapham-Tooting section of the Morden tube extension. Two of the new stations—Balham and Trinity-road—will be entirely below the surface; the others—Nightingale-lane and Tooting Broadway—will have booking halls at ground level. All will be equipped with escalators. Meanwhile steady progress can be recorded in the driving of the new 4½-mile long tunnels between Clapham Common and Merton Grove, where the line will emerge to the surface. Rotary excavators are being employed capable of boring a total of 1,400 ft. of tunnel weekly. On the open sections work is proceeding apace, but at Morden the erection of the car sheds has been rendered difficult owing to the exceedingly heavy rains. Despite these difficulties, the company expect to open the line for traffic in December of the present year, according to schedule.

2-8-2 EXPRESS PASSENGER AND FREIGHT ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.

CONSTRUCTED AT THE COMPANY'S ALTOONA WORKS; MR. J. T. WALLIS, CHIEF OF MOTIVE POWER.

(*For Description, see Page* 125.)

Fig. 1.

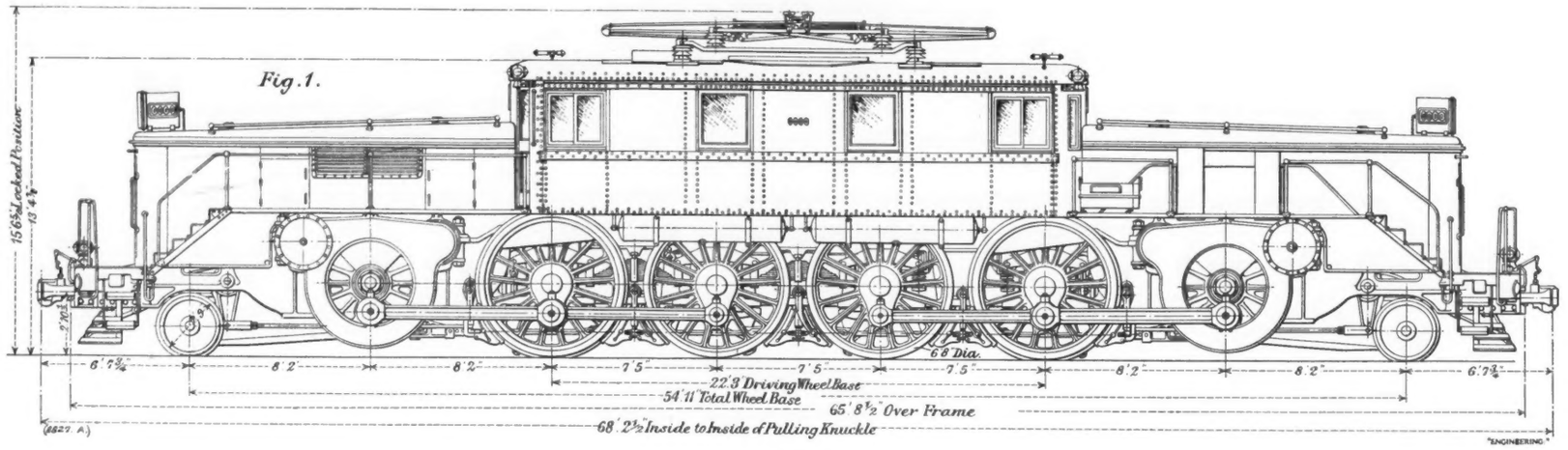


Fig. 2.

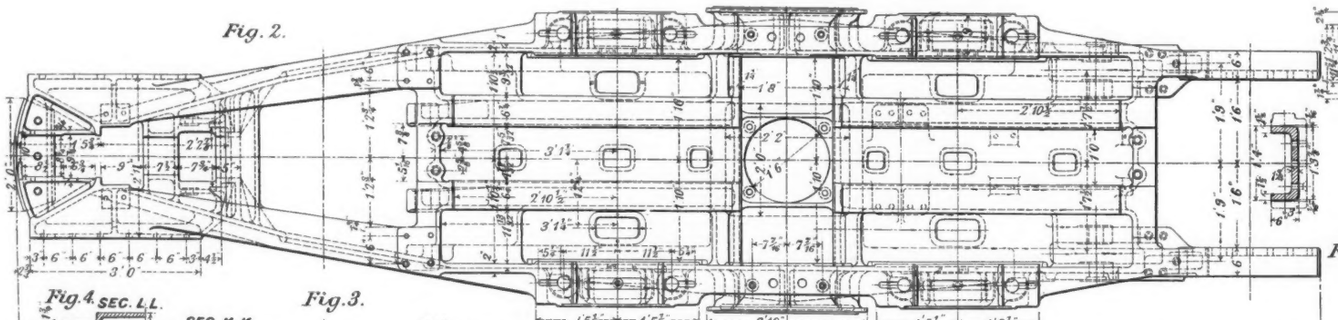


Fig. 3.

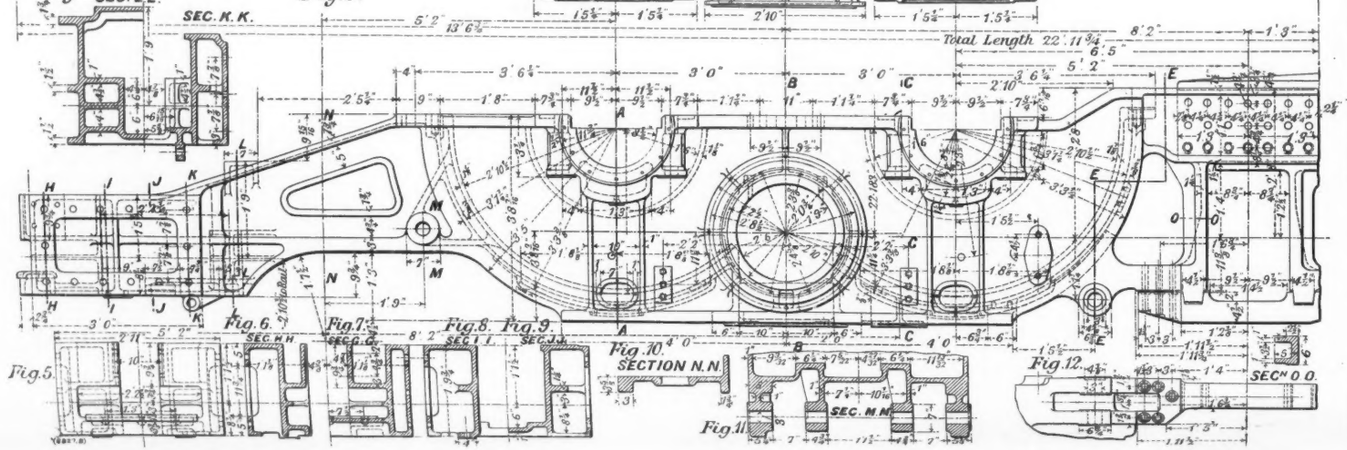


Fig. 4. SEC. L.L. SEC. K.K.

Fig. 5

Fig. 6. SEC. H.H

Fig. 7. SEC. G.G

Fig. 8. SEC. I.I.

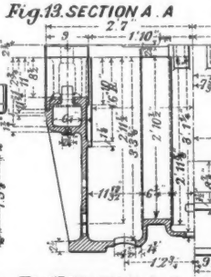
Fig. 9. SEC. J.J.

Fig. 10. SECTION N.N.

Fig. 11.

Fig. 12.

Fig. 13. SECTION A.A



SECTION B.B Fig. 14.

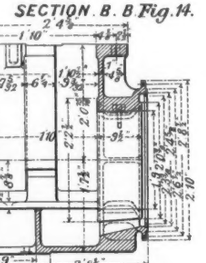


Fig. 15. SECTION C.C. SECTION E.E. Fig. 16.

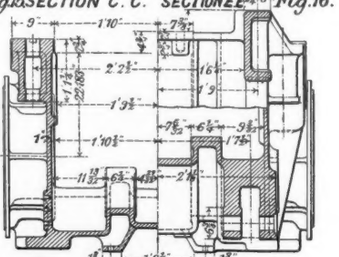


Fig. 17. SECTION F.F. F.F.

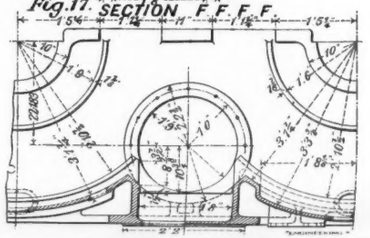


Fig. 18.

Fig. 23. SECTION P.P. SECTION Q.Q.

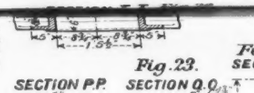


Fig. 24. SECTION R.R.

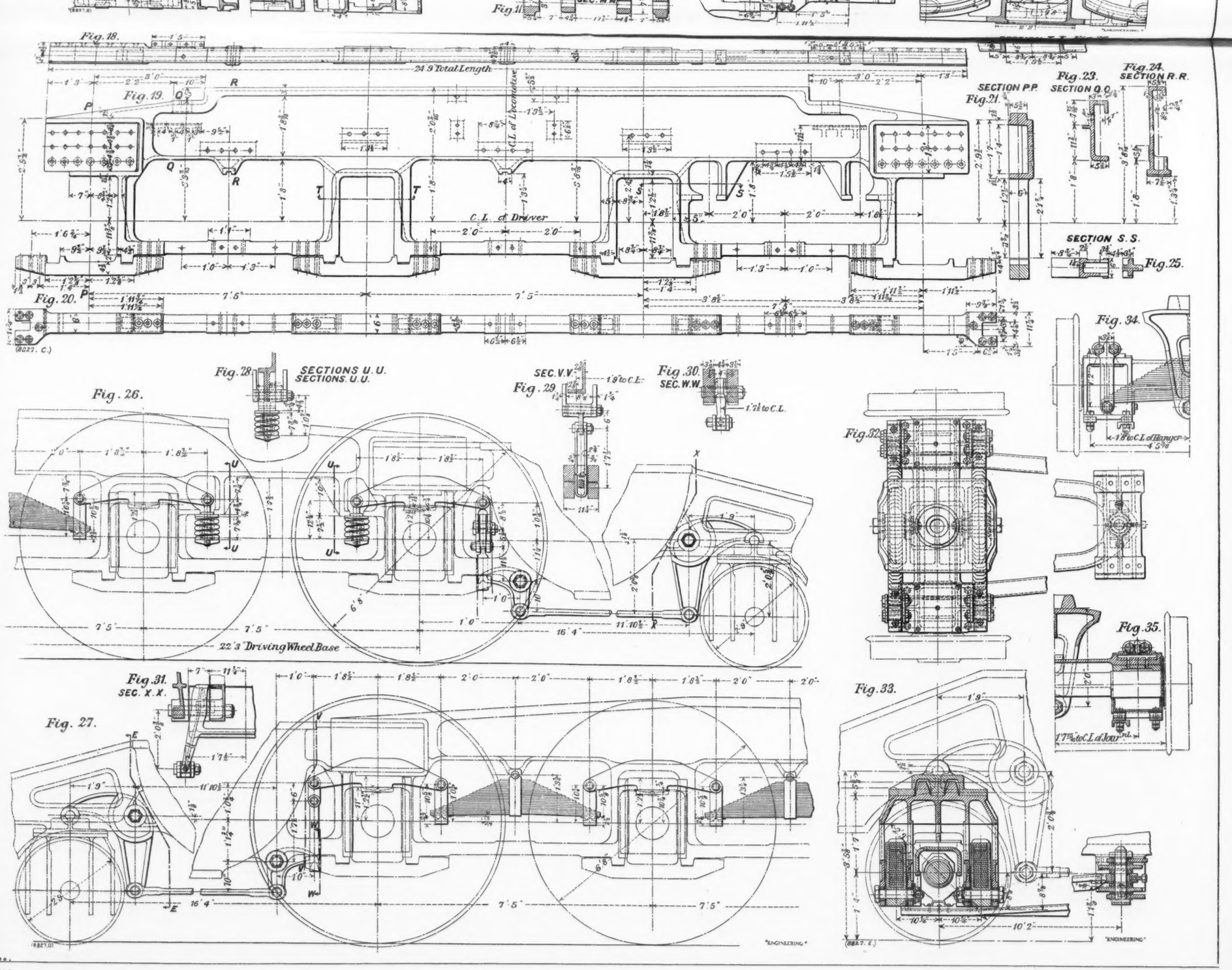


Fig. 18.
24'9" Total Length
Fig. 19.
C.L. of Locomotive
C.L. of Driver
Fig. 20.
Fig. 21.
SECTION P.P.
Fig. 23.
SECTION Q.Q.
Fig. 24.
SECTION R.R.
SECTION S.S.
Fig. 25.
Fig. 34.
1'8" to C.L. of Hanger
4'5⅛"
Fig. 26.
Fig. 28.
SECTIONS U.U.
SECTIONS. U.U.
Fig. 29.
SEC. V.V.
1'9" to C.L.
Fig. 30.
SEC. W.W.
1'7½" to C.L.
Fig. 32.
Fig. 35.
17⅝" to C.L. of Journal
22'3" Driving Wheel Base
Fig. 31.
SEC. X.X.
Fig. 27.
Fig. 33.
"ENGINEERING"

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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Two-Page Plate.—2-8-2 *EXPRESS PASSENGER AND FREIGHT ELECTRIC LOCOMOTIVE ON THE PENNSYLVANIA RAILROAD.*

ENGINEERING.

FRIDAY, JANUARY 30, 1925.

CUTTING TOOLS.

ALTHOUGH the practical man, who knows what can be done with cutting tools of various types, may think that there has been a surfeit of research into their action, we are still very far from knowing all there is to be learnt about cutting metals. Nearly always, hitherto, attacked from the point of view of maximum cutting power, many of the investigations have undoubtedly stimulated the use of high-speed steel, and have also aided in the development of modern machine-tool design. As pointed out, however, by one of the speakers at last Friday's meeting of the Institution of Mechanical Engineers, a very large proportion of engineering work is not done with roughing cuts at maximum output, and even to engineers interested in these, the subject of accurate cutting is also of considerable importance. This side of the question is now to receive some attention, and since it is the work we want, and the tool is only a means to an end, it seems logical to examine into the effect of tools on the metal cut, to see if anything can thus be learnt which may point to further improvements. Both of the reports presented at last Friday's meeting, reprinted elsewhere in this issue, concentrated upon the effect in the metal cut, and thus give some degree of novelty to the subject. That it is not quite novel appears from the fact that Dr. Rosenhain, so long ago as 1906, published a microphotograph, showing how metal behaved under the action of a tool, but this excursion into the field does not appear to have been followed up.

It is rather curious that the exceedingly pretty demonstration given by Professor Coker some two years since at the Institution was not referred to in either report and only mentioned by one speaker in the discussion. If we are not mistaken, Professor Coker's experiment on celluloid discs first attracted attention to the fact that little was known about the distribution of stresses in the metal acted upon. Although celluloid was used with glass tools, the demonstration certainly appealed to many engineers whose everyday work involves the handling of very different types of material. The beautiful method adopted by Dr. Rosenhain and his collaborator, Mr. Sturney, carries the work a good deal farther, and has the advantage of providing a type of permanent record which will probably prove attractive to a rather wider circle. The difficulty of ensuring proper conditions right up to the final point of cutting, would seem to set a limit to the system of working so far used, but even so, it has been proved capable of bringing out interesting facts. The report we now refer to is clearly preliminary in character, and it is not to be expected that it should cover and solve all the moot points regarding cutting actions.

In a very general way and on quite broad lines we wish to refer to one or two points arising out of it, which seem to be of interest and possibly may lead to further developments. If a flat plate be placed in a moving fluid, at right angles to the line of flow, the stream diverges to either side, while a cone of comparatively immobile fluid develops in front of the plate. If the surface be tilted, as is well known, the centre of pressure moves towards the leading edge, and the regular cone changes to one having a short side towards the front edge, and a long slope towards the tail. The farther the plate is turned the greater will be the advance of the centre of pressure, while if the plate be edge-on, the stream will suffer a minimum of disturbance. While it may be a long step from the fluid which one usually has in mind in such connections to metal moving past a tool, some of the photographs of Mr. Sturney and Dr. Rosenhain certainly remind one of the development of the cone referred to above. Probably, indeed, the analogy is closer than might at first sight appear, since the stresses involved are probably sufficient to induce plasticity, and no definite distinction can be drawn between a plastic solid and a viscous fluid. These photographs show in a very interesting manner how a roughly triangular zone of immobile metal builds up on the tool under certain conditions of cut, and how this varies with the degree of top rake.

Conceiving the moving metal to be the stream, into which the flat tool surface is inserted to a limited depth, it is found that this zone has a short leg leading to the tool nose, and a long limb tailing off into a direction parallel with the tool surface. The metal cut is, of course, constrained on one side and free on the other. It its distribution, the load on the tool, therefore, diminishes from the point towards the rear. The position of the apex or hump of the triangular zone would appear to correspond with the centre of pressure as suggested by the streamline analogy, and the characteristics of the zone itself are approximately those of comparatively motionless matter. In this area the metal would seem to be in a state of plastic flow under intense local pressure. Several of the photographs in the report support the analogy. For instance, some show lines of movement along the long back of the wedge running out into the underside of the turning as it moves over the tool. Other lines again move inwards from the hump or apex, towards the work, and, passing over the nose of the tool, are incorporated in the outer skin of the reduced diameter. The latter are probably indicative of one of the effects which lead to blunting. If the train of ideas, set forth above, is logical, the explanation of the protection afforded by the zone of deformation is apparent. The report suggests that this zone is stationary on the tool; the plastic flow we have considered would imply relatively small movement and therefore comparatively small destructive effect. This would account for the lasting power of the tip, though immediately beyond the tail of the zone serious grooving due to rapid slip over the surface, may result in the quick destruction of the tool.

A difficulty may be thought to arise at the lip end of the zone. Here cracks develop and run into the metal, producing an irregular surface accepted as the cut. Such cracks recur intermittently. When they do form, a zone of plastic flow moves away with the chip. It would be while

the next zone is building up that metal would tend to flow over the lip of the tool to be pressed into the finished face.

It is evident that the shape of the zone of plastic flow is roughly similar to the accumulation of metal which under some circumstances builds up on and becomes adherent to the nose of the tool. In the cases examined in this report speeds were low and cuts light. The actual adhesion of the metal depends upon a variety of conditions of heat, pressure and so on, about which little is at present known. The interesting point arises, however, that whether adherent to the tool or not, this zone builds up until a certain shape is reached for a particular metal, cut and rake. If built up on the tip this new slope will be retained in preference to the actual rake. If the rake be altered to a slope corresponding with the back of the zone, the area of plastic flow disappears. Such conditions, according to Dr. Rosenhain, lead to the rapid wear of the tool since the whole of the top is exposed to the abrasive action of the chip. Here, however, there is some divergence of opinion for, according to Dr. Rosenhain, in some cases "flow" conditions with rapid abrasion set in with a top rake of 15 deg. or so, though, as Mr. P. V. Vernon has previously pointed out, capstan and other lathes employ 35 deg. top rake as the most economical for output and durability combined. The reconciliation of these two contentions would seem to be desirable.

As is well known, the wider use of curved top face tools is advocated in many quarters. These are especially popular on the Continent. The former objection to them that they cannot be accurately reproduced of course no longer holds. The principles of this system of grinding tool faces were discussed in detail in ENGINEERING, Vol. CXII, page 213. The advantages lie in the fact that for equal rake at the lip they are superior to the usual straight tool in heat-dissipating qualities, owing to the greater backing of metal behind the tip; the latter is, of course, formed in the one case by a curved surface and in the other by a plane tangential to the curve. The curve is also considered to give a good lead to the chip. Dr. Rosenhain points out that as regards finish large top rake tends to less irregularity; Dr. Stanton points out that it also means reduced normal pressures. Both these features, therefore, should be characteristic of the curved top face tool. Whether these tools would fail by abrasion owing to the large top rake, or whether a modified deformed protective zone forms over the lip, seem to be points worthy of consideration, and the claims made for reduction of driving power are also a fit subject for investigation. At so early a stage one naturally hesitates to suggest complicating the research, especially when the possible variations of curvature are so numerous, but the investigation of the nature of the chip so far carried out certainly suggests that we might learn something in this way of the actual value of the features which, apart from higher conductivity, are claimed to give these tools superiority.

THE OIL POLLUTION OF COASTAL WATERS.

IT is a common experience for an engineering development possessing many important advantages to be accompanied by one or more drawbacks of a comparatively minor character the effects of which are particularly difficult to eliminate, and the use of oil fuel for marine propulsion is no exception to this rule. The advantages of oil fuel for the propulsion of certain classes of shipping are numerous, and the fact that they are generally appreciated is indicated by the increase in tonnage of vessels fitted with oil-fired boilers, or with internal-combustion engines, during the last decade. The one drawback to which we wish now to refer arises mainly from the discharge of oily water from ships' tanks which are used alternately for water ballast and oil fuel, although other causes exist, as will be seen later. In any case the heavy oil which collects on the sea water is eventually deposited on the foreshore, particularly in the neighbourhood of busy ports, where it interferes with the amenities of seaside resorts, and is destructive to certain forms of marine life, as well as to aquatic birds. The nuisance which became serious towards the end of the war, so increased subsequently that to mitigate it, as far as the territorial waters of the United Kingdom were concerned, the Oil in Navigable Waters Act was passed.

Quite recently the subject has been considered by a joint committee appointed by the Chamber of Shipping and the Liverpool Steamship Owners' Association, who have just issued a report dealing with the causes of oil pollution of the coasts of this country, and offering some suggestions as to the action which should be taken to prevent or to mitigate it. They express the opinion that while the discharge from merchant ships is one of the factors which produce pollution, its effect has been exaggerated, and that a more serious source of trouble arises from the cleaning out of oil tanker vessels and from vessels carrying fuel oil and water ballast alternately in their double-bottom or other ballast tanks. Naval vessels, they also suggest, have been largely responsible for oil pollution, although Admiralty orders were issued in March, 1923, and in May of last year for the purpose of reducing the nuisance. These orders, however, do not prevent oily water from naval vessels being pumped out on the high seas. Another source of pollution which is not amenable to any form of control arises from marine casualties. It is sometimes necessary if a ship grounds to pump out her fuel oil for lighting purposes, and oil may escape from the tanks of a sunken vessel long after the time of the accident. In this connection it may be of interest to mention the fact stated in the report that in many districts, oil pollution is found to increase after a spell of heavy weather. This the committee ascribe to the release of oil from the tanks of vessels sunk during the war. As they become further broken up by the action of the sea.

In referring to the methods available for dealing with the question of oil pollution, the committee express satisfaction with the working of the Oil in Navigable Waters Act, above referred to, in connection with separating barges provided by the various port authorities. The Act has proved effective in preventing the discharge of oil within the territorial waters of the United Kingdom, and it is recommended that those other countries which have not yet passed similar legislation should do so. If this was done, however, the question of the discharge of oil on the high seas would be still left open. Any legislation on this point, it is thought, should apply only to crude petroleum, fuel oil and Diesel engine oil, and, following the opinion expressed by the Admiralty, the committee tentatively suggest a distance of 150 miles from the coast as the limit within which the discharge of such oils should be prohibited by international legislation.

Considerable attention has been given by the Committee to the question of fitting oil separators on board ships, and their recommendation on this matter is that the compulsory fitting of such separators is undesirable. While existing types of these appliances are generally capable of extracting the oil and discharging clean water overboard they do not appear to be capable of completely separating oil and water in a state of emulsion, a fact which materially affects the value of the oil recovered. With certain mixtures the recovered oil is usable, but it is generally of little commercial value. This applies also to the separating barges provided by port authorities, although they have been quite effective in presenting harbour pollution. One of the Committee's recommendations is to the effect that separating barges or other receptacles, should be provided in adequate numbers at all ports frequented by oil-driven or oil-carrying ships. Other recommendations are that identical regulations should be agreed upon and enforced by all maritime countries; should apply only to crude petroleum, to fuel and Diesel oils; should be enforced by a compulsory record in the ship's log of the pumping of oily ballast water and tank washings; and that the naval authorities in all countries should impose corresponding regulations on naval craft. Nedless to say any regulations relating to privately-owned merchant ships should be applied equally to state-owned ships other than fighting vessels.

As might be expected, similar conditions affecting the pollution of coastal water by oil exist in the United States as have been experienced in this country. The matter has, therefore, been investigated by the Bureau of Mines and a report on their investigations was presented before the Annual Convention of the American Association of Port Authorities at Los Angeles, in October last. The investigations extended over the Atlantic, Pacific and Gulf coasts and covered the effects of oil fields and refineries, oil-distributing stations, gas works, railways using oil fuel, and natural sources of oil pollution, as well as oil-burning ships and tankers.

In general, the conclusions reached as regards shipping are very similar to those outlined above, except that no special reference is made to the operations of naval vessels. The reports states that the discharge of oil-contaminated ballast water is believed to constitute the largest proportion of the oil pollution arising from ships and that oil-contaminated bilge water is relatively unimportant. The Bureau's investigators regard separator barges as the most practicable method of dealing with oil-contaminated ballast water and oil refuse, but state that owing to the low value of the recovered oil some form of assistance would be necessary for persons or organisations owning and operating such barges. An estimate of the operation of the barge system in New York Harbour indicates that the total cost would amount to about 70 dols. per vessel per call. The opinion is expressed in the report that a separator for use on shipboard can be developed of sufficient efficiency to enable the separated oil to be used directly as fuel, although it is doubted whether any existing type of apparatus can be unreservedly recommended for installation on general cargo vessels. The conclusion on this point is that the ultimate solution of the problem will involve the use of oil and water separators on each individual ship in combination with the provision of facilities in harbours for the disposal of heavy sludges and some other forms of oily wastes, which separators will not deal with effectively.

THE RATING OF MOTOR VEHICLES.

MODERN economic relationships render it almost impossible to legislate for one particular class of the community without indirectly affecting many others. An example of this is seen in the motor vehicle tax, which has an effect which extends far beyond the actual vehicle owner, and may even affect the national prosperity. The importance of motor vehicle transport has been repeatedly brought home to the general public in times of national emergency, but its effect in more normal periods is frequently overlooked. It will hardly be disputed that every pound added to the vehicle tax must increase the cost of every article which is subject to transport by road, either during the period of manufacture or on completion, and it might be argued that a reduction in transport costs brought about by a remission of the entire duty would result in an increased general prosperity which would more than compensate for the loss of revenue from the tax. We are not concerned here with the soundness of this assumption, but merely quote it to bring out the fact that the vehicle tax is a matter of concern to every individual in the community. Apart from this aspect, in so far as the tax affects the development of design in any particular class of vehicle, it influences our export trade in that class according to whether it tends towards the development of a design which is suitable or otherwise for the conditions prevailing in foreign countries. In a paper read before the World Power Congress, which we reproduced in our issue of December 26 last, Mr. H. G. Burford suggested that the governing factor in design was the state of the roads in this country rather than our form of taxation, but it is generally agreed that the latter is at least a contributory factor.

The general attitude of both the authorities and the public is that the vehicle tax is an economic necessity at the present time, but there is a considerable amount of dissatisfaction prevailing

concerning the basis which determines the actual amount of tax payable by the owner of any particular vehicle. The question has been a subject of considerable controversy for many years, and the number of alternative methods of taxation which have been suggested from time to time is very considerable.

The gross revenue from this form of taxation amounted to some 13 million pounds in 1923, and although the figures are not yet fully available, it is probable that the corresponding figure for 1924 will not fall far short of 15 million pounds. As is well known the whole of this revenue is allocated to road maintenance and improvement, and agreement is fairly general that in view of the urgent necessity for these improvements, the gross income from this source should not be subject to any substantial reduction in the immediate future. On the other hand, there is a pronounced feeling in many quarters that the basis of taxation, particularly in the class of private cars, is inequitable.

The present system of taxation was embodied in the Finance Act of 1920, and under this Act motor-cycles and commercial vehicles are taxed on a weight basis, hackney carriages on seating accommodation, and private cars on horse-power. In round figures, in 1923 owners of private cars contributed some 6 million, commercial vehicles 4 million, motor-cycles 1 million, and hackney vehicles 2 million pounds to the national revenue. It will thus be seen that owners of private cars are the heaviest contributors to the total, and it is more particularly in the possibility of devising a more equitable basis of taxation in this class that the public are particularly interested. It is probable that the authorities would offer no objection to a new basis of taxation with regard to this class of vehicle so long as the general incidence of taxation as between the various categories of vehicle was not disturbed.

There is a widespread impression amongst the motoring public that the question has not received adequate attention from the authorities on the one hand, and the various interests representing the motoring public on the other. Such an impression is not unnatural in view of the fact that the cylinder bore has formed the basis of taxation for a considerable number of years, and a minimum of technical knowledge suffices for the conclusion to be reached that this basis is theoretically unsound. Far from the question having been neglected, however, it has been the subject of the most careful and unremitting consideration on the part of the authorities, and a Departmental Committee was appointed to investigate the question by the Ministry of Transport in 1919, which has published interim reports on several occasions since that date. The extremely intricate nature of the work undertaken by this committee, and the complexity of the issues involved, is clearly brought out in a paper on "A Review of the Rating Question" read by Mr. A. E. Berriman before the Institution of Automobile Engineers last Tuesday. In this paper the author gives an admirable summary of the whole rating question as it stands to-day, and a good deal of misapprehension on the part of the motoring community might be removed if the more salient features of the paper were to be broadcasted.

As an alternative to the present system of taxation on cylinder bore that which makes the strongest appeal to the public is a fuel tax. The equity of such a tax can be appreciated by almost anyone, but it is much more difficult to arrive at a just conception of the difficulties involved in its application. The opportunities for the evasion of the tax in the event of its being applied to only one class of vehicle are so obvious that it is doubtful whether they could ever be overcome by legislation, and if, on the other hand, the tax was to be universally imposed irrespective of the class of vehicle, it will be evident that commercial and hackney vehicles would be placed in an unfavourable position as compared with that which they enjoy under the present system of rating. This will be clear when it is realised that the average annual mileage of such vehicles is much greater than that of private cars. Any system of differential rating under a fuel tax for different classes of vehicles would again offer opportunities for evasion, although it will be evident that the loss of revenue from this cause would not be so great as that which would result from the fuel tax being applied to one class of vehicle only. A further serious obstacle in imposing a fuel tax lies in the difficulty of defining motor fuel, and in this connection Mr. Berriman remarks that an exact technical specification presents immense difficulties, although he does not regard the solution of this problem as insuperable.

The usual objection to the present tax based on cylinder diameter is that it bears with undue weight on those owners who for any reason attain only a small annual mileage, and that it unduly hampers the freedom of the designer. We incline to the opinion that undue stress is apt to be given to both these aspects of the question. As regards the owner who makes only a limited use of his car, it must be remembered that a very wide range of types is available to the potential purchaser, and that he has perfect freedom in selecting the particular type which most nearly conforms to his needs. Thus if a car is bought for occasional use only, one having a small bore high-speed engine would naturally be indicated, and if a car having a relatively large bore engine is purchased instead, it is to be presumed that the purchaser considers that the features associated with such an engine outbalance the higher annual tax.

As regards the second consideration, we have already referred to the fact that the present basis of taxation may tend to develop a type of vehicle which is unsuitable for the conditions existing in foreign countries, but it is always open to the British manufacturer to cater for the foreign market by developing a special design. Apart from this, there is no question but that the manufacturer catering exclusively for the home market has benefitted by a form of taxation which tends to eliminate competition from foreign manufacturers who install a large-bore engine to suit the conditions prevailing in the country of origin. We do not wish to suggest that the present basis of taxation is necessarily the best, but as Mr. Berriman points out, it behoves the makers of a change in this direction to ensure that a new system is not only better than the old, but so much better as to justify the inevitable commercial disturbance.

Apart from the fuel tax, the alternative systems of rating, suggested from time to time, may be divided into two main groups, comprising in the first instance various alternative engine ratings, and in the second, ratings which refer to the car as a whole, as distinct from the engine as a unit. The latter may be said to be more rational than the present basis, as this ignores the possible effect of such factors as engine stroke, transmission ratio, and wheel diameter. The simplest form of car, as distinct from engine tax, would be one based on weight only, but as this entirely ignores the effect of speed the tax paid under such circumstances would bear no relation to the potentialities in the direction of road destruction, a principle which is obviously involved in the idea that the proceeds resulting from the tax should be devoted to road maintenance. The car rating formula discussed in the paper referred to is obtained by multiplying together the cylinder capacity and the final reduction ratio, and dividing the result by the effective tyre radius. Such a formula would give the designer increased latitude, as it would enable him to vary the stroke-bore ratio or even the total capacity of the engine, so long as the product of the capacity and reduction ratio, divided by the effective tyre radius, was unaltered. A formula involving such a large number of variables would involve considerable inconvenience in making a declaration in the case of old cars, and a periodic examination of all cars on the part of the taxation authorities would also become a necessary proceeding which would inevitably prove both costly and inconvenient.

The conclusion reached by Mr. Berriman is that the fuel tax would be by far the best system, and that every endeavour should be made to remove the obstacles that now prevent its adoption, but that so long as the fuel tax is impracticable, it seems preferable to retain the known conditions of the present system rather than risk the reactions of a change. We believe the same conclusion will be reached by the majority of people, but also fear the difficulties involved in the imposition of an equitable fuel tax are almost insuperable.

THE PHYSICS OF THE INTERNAL-COMBUSTION ENGINE.

THE cause of the defect of pressure in gaseous explosions has frequently been the subject of conjecture, and in a previous issue (page 70 *ante*) Mr. Melencovich made certain suggestions which are, we fear, more ingenious than illuminative. One at least of his three hypotheses would seem to be in direct conflict with well-established physical and mechanical principles. Thus Mr. Melencovich suggests that "the heat freed by the combining atoms attracting each other to form molecules appears in the first instance mainly as rotational energy." There will be, he continues, "a violent rotation of the two atoms about their common centre of gravity," so that "the newly-formed molecule will have an excess of rotational energy." Now it is a fundamental principle in mechanics that no rotation of a system as a whole can be produced by the mutual attraction of its parts. The contrary view was, no doubt, promulgated by Herbert Spencer, and constituted one of the worst of his many misconceptions. The proposition, that rotations can thus be produced is, in short, in direct conflict with Newton's laws of motion.

It is, of course, quite true that if we used a wooden ball, suspended by a string, as a ballistic pendulum, darts shot into it, would in general give rise to some rotative effect. This would, however, no longer be the case were the relative motion of the ball and dart entirely due to a mutual attraction. In short, action and reaction being equal and opposite, no momentum, either linear or angular, can be generated in such a system, taken as a whole, by mutual attractions. Hence, it is quite impossible to accept Mr. Melencovich's assumption, that the chemical energy of combining molecules, will, in the first instance, be expended in producing large excesses of rotational energy. In the second place, Mr. Melencovich is certainly in error in asserting that such excesses, if they existed, would not be rapidly extinguished by molecular collisions.

If we understand him correctly his view is that the total amount of rotational energy being $h\nu$ quanta, the whole must be parted with in one collision; that it is, in short, a case of all or none. If this is what he means, it is incorrect, and, whilst there is no reason why a very large fraction of such an excess of energy should not be carried off in a single collision, there is nothing in the doctrine of quanta to bar the energy being parted in a series of successive encounters. According to the quantum theory of molecular rotation the energy due to the spin must be proportional to the squares of the natural numbers; but this is the only restriction, and the rotating molecule can part in one operation with energy proportional to the differences between the squares of any two integers. The energy of radiation on the other hand is directly proportional to the natural numbers and not to their squares, so that in this case energy may be parted with by steps of single quanta. This may occur when light is reflected from a moving mirror. In such case the wave-length of the reflected light is not the same as that of the incident light, and the number of quanta corresponding to the energy of the ray is correspondingly increased or reduced.

THE LATE SIR GUILFORD MOLESWORTH.

SIR GUILFORD LINDSAY MOLESWORTH, who had strong claims to be considered the *doyen* of the engineering profession and whose name was probably more generally familiar than that of any other engineer of our day, died on the 21st inst., at the Manor House, Bexley, to which he had retired

on relinquishing the pursuit of active work. Born on May 3, 1828, Sir Guilford had long passed the span of life allotted by the Psalmist, but having been endowed by nature with extraordinary physical vigour, he escaped almost entirely the penalties which too frequently attach themselves to an exceptional prolongation of life. When at the age of 70, after a life time of hard work, spent largely in the tropics, Sir Guilford was asked to report on the Uganda Railway, he covered the ground mostly on foot or bicycle, and did so without any ill effect. On one of the hottest days of the Uganda summer, he rode on one occasion 46 miles, without experiencing any fatigue, although the prevalence of thorns on the track prohibited the use of pneumatic tyres. Again, during 1915, at the age of 87, he worked for five months in the offices of Messrs. Vickers at Crayford, daily from 9 a.m. to 4 p.m., being finally stopped by his doctor.

Like the late Sir Benjamin Baker, Sir Guilford was of Anglo-Irish stock, but he was himself born at Milford, near Southampton, where his father held a curacy. He was one of a family of nine, and his wish was to enter the Navy. As one brother was already in that Service, his father demurred, and decided that he should take up the profession of engineer. In settling on the course of training to be followed, the father appears to have shown exceptional intelligence and wisdom. We have grown accustomed to think that the technical school, equipped with workshops and laboratories, is quite a modern institution, but this is an error. In 1844, Molesworth was entered at a civil engineering college at Putney, which had a workshop, a foundry, a laboratory, and a museum, and which included on its staff the late Lionel Playfair. The college did not, however, prove a financial success, and was closed shortly after Molesworth left it. The period was that of the railway mania, and senior students were impressed for surveys, and were paid from 5 to 10 guineas a day for their services. Molesworth can hardly be said to have distinguished himself at college, but his report described him as a "studious painstaking person, whose conduct was uniformly satisfactory." This verdict was amply confirmed in his later career, and the qualities described eminently fitted him for service under Government.

On leaving college, Molesworth was engaged under Mr. Dockray on the widening of the London and Birmingham line, near Watford, and later on he was engaged as assistant to Mr. H. Warriner in constructing a branch line. His father was then advised that workshop experience was essential to an engineer's education, and sent him accordingly, to Fairbairn's works, in which he passed a couple of years. This experience he subsequently found invaluable, and it convinced him that a similar course should be taken, if possible, by every civil engineer. To-day this is probably impracticable. Specialisation rules everywhere, and seems unavoidable, but it nevertheless remains true that the knowledge of materials acquired in the workshop is attainable in no other way.

On leaving Fairbairn's works, Molesworth acted as chief assistant to Mr. Doyne, who was engaged on railway work in South Wales. Subsequently he became chief assistant engineer on the widening of the London, Brighton and South Coast Railway from London to Croydon. In this work he had his first experience of the irritating and unexpected vagaries of the London clay when exposed to atmospheric influences.

About this time the Crimean War had given rise to difficulties at Woolwich. More munitions were needed, new factories were urgently required and Fairbairn was asked to nominate a man for the work. He recommended Molesworth, who accepted the post only to find himself hampered at every turn by his Royal Engineer superior. Shells were urgently required, and by hard work Molesworth in two days got out drawings for the new factory. On submitting these to his chief, the latter demanded a new set of drawings, as he thought the windows might be spaced a little wider. When these were made, still another set of drawings was required, as the windows might be a little narrower. This practice was repeated day after day, and at the end of a month the work was no further forward than on the second day. The erection of a new saw mill was similarly obstructed and all the time the army was suffering from shortage of munitions. The whole episode reads curiously like a rehearsal of many similar incidents in 1914 and 1915.

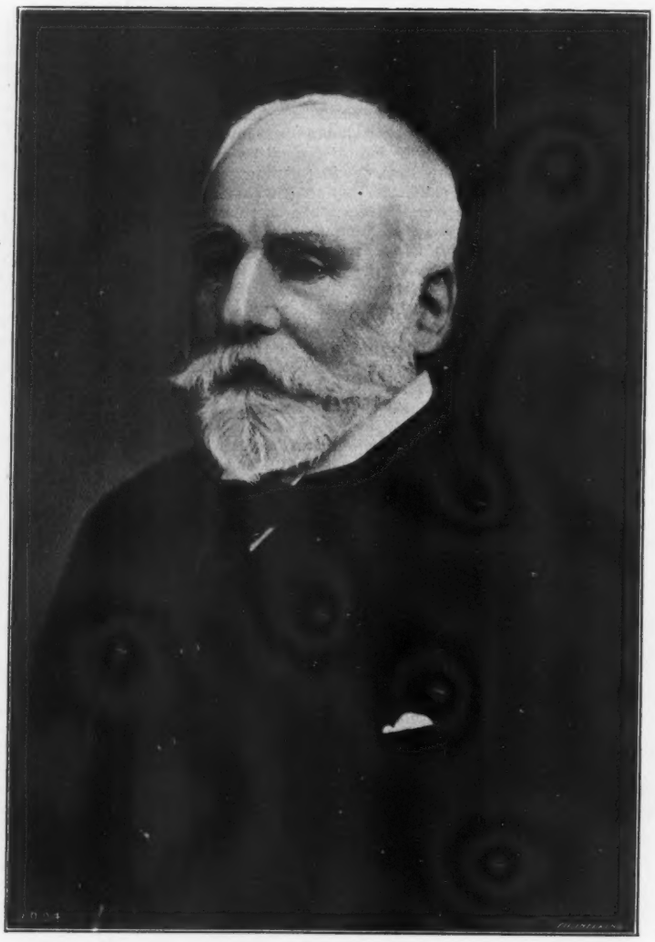

Photo. by Elliott and Fry.

THE LATE SIR GUILFORD MOLESWORTH.

After leaving Woolwich, Molesworth practised for some years as a consultant, being for the most part engaged in "devilling" for better known men. In 1859, however, he was appointed chief engineer to the Ceylon Railway Company. A route had already been selected for the new line, but Molesworth had additional surveys made, and discovered a better route. Financial difficulties led to the transfer of the undertaking to the Government, and Molesworth left Ceylon in 1861 not expecting to return. Two years later, however, the Ceylon Government appointed him Chief Engineer for the construction of this very railway, and he was subsequently made Director-General of Railways and of Public Works.

In connection with his railway work he had one very alarming experience. The Duc de Brabant afterwards King of Belgium, was being taken over the line and Molesworth was driving the engine. He suddenly, on rounding a bend, found that a mass of stones had been piled on the line, with the object of wrecking the train. It was impossible to stop, and all that could be done was to charge the obstacle and trust to luck. Fortunately the train kept the rails, and it was considered advisable to hush the matter up.

In developing the Ceylon railway system, Molesworth adopted the policy which was so largely pursued by the pioneer lines of America, viz., the making of improvements and extensions out of revenue in place of raising fresh capital. When, later on, he acted as technical adviser to the Indian State Railways, he advocated the same course. In England, such a policy can only be followed to a limited degree as it is not favoured either by the Law Courts or by Somerset House, and would probably also be denounced by the trading community, who prefer the immediate good of improved facilities or reduced rates, to the prospect of still greater advantages at some unspecified later date.

Curiously enough, Molesworth considered that the best work he did for Ceylon was the introduction there of a decimal coinage. As a matter of fact,

however, the advantages of this are somewhat doubtful. This is especially the case with so important a neighbour as India close by.

It was in 1871 that Molesworth went to India as Technical Adviser for the State Railways. Prior to his advent, there had been a furious battle of the gauges, in which the victory had rested with the advocates of the metre gauge. To this Molesworth was known to be opposed, and on his arrival, accordingly, Lord Mayo informed him that the question was a *chose jugée*, not to be reopened. As in another celebrated case, however, the actual facts proved too strong for officialdom. When the Afghan War broke out, the confusion arising from the break of gauge was so disastrous that over 1,000 miles of line had to be converted to the broad gauge. Lord Roberts, it may be added, had strongly protested against the break of gauge, but as in the more recent case of the first disastrous Mesopotamia campaign, the Indian Treasury held itself superior to the opinions of the experts.

Molesworth remained in India till 1889, his service being extended for another 5 years when he reached the usual age of retirement. During this time the construction of over 4,000 miles of State railways was sanctioned, and of this some 3,450 miles were opened to traffic before he left. His services were rewarded with the K.I.C.E. Being a civilian, his appointment had been resented by a certain section of the Royal Engineers. This opposition led to Kipling's famous verses in which the "little tin gods" were described as maintaining that "only a colonel from Chatham can manage the railways of State." On the whole, as a matter of fact Molesworth got on very well with his Royal Engineer colleagues, owing, no doubt, largely to his winning personality.

On his return to this country he took up consulting work. He was, moreover, appointed as one of the arbitrators in a dispute between the Siamese Government and a railway contractor. For a time matters progressed smoothly, but the proceedings were ended owing to the dishonourable and dishonest conduct of a German engineer engaged on the same case. The matter in debate had, therefore, to be settled in another way. He was President of the Institution of Civil Engineers in 1904–5, and on concluding his term of office definitely retired from active practice.

So far we have made no mention about the work which more than any other made Molesworth's name a household word to more than one generation of engineers. Fifty years ago every draughtsman, whether concerned with civil or with mechanical engineering, possessed a copy of Molesworth's "Pocket Book of Engineering Formulæ." The work for long had no serious competitor amongst English publications. It originated in a recommendation made by Mr. Dockray in 1849 that Molesworth should keep a commonplace book in which he should enter every thing of interest down to the dimensions of a wheel barrow. The collection of notes grew as years passed, and when Molesworth returned home from Ceylon in 1861 he conceived the idea of publication and prepared his notes for the press. It was first offered to Weales', who declined to have anything to do with it, but Messrs. E. and F. N. Spon proved more enterprising and issued it in 1862. No contract was entered into or any definite terms arranged, but Molesworth has expressed himself as very satisfied with the honourable and generous treatment he received. The first issue ran to 220 pages. Six editions were called for in the course of twelve months, and almost innumerable new editions since, in the course of which the work has been repeatedly revised and enlarged as necessity demanded.

THE LATE MR. C. H. WORDINGHAM.

WITH great regret we have to record the death on Wednesday morning of Mr. Charles Henry Wordingham at the comparatively early age of 58 years. Mr. Wordingham was one of the best known electrical engineers in the country, and his loss will be widely felt. Despite the fact that he was born only in 1866, his career covered almost the whole development of electrical engineering, as in his early days he was third engineer at the Grosvenor Gallery generation station. The main outlines of his subsequent work as City Electrical Engineer to Manchester, Head of the Electrical Department of the Admiralty, and as one of our leading consultants will be generally known, but his remarkable energy led him to lend very useful support to many activities. We will publish a full account of his career in our next issue.

NOTES.

SCIENCE AND INDUSTRY.

PROGRESS in industry through the application of scientific work is so rapid that the whole practice in any particular direction may undergo a complete revolution in the course of a few years. What was recently a discovery of purely academic interest may quickly become so intimately associated with ordinary life that everyone accepts its use and depends on its action as mere matters of course. This was the theme taken for his speech by Dr. C. H. Desch on Saturday last at the annual dinner, in Huddersfield, of the West Yorkshire Metallurgical Society, and he illustrated his argument by citing some examples. Tungsten wire was used to-day, he said, in electric lamps and was put through processes to suit this application, which were quite incredible to chemists and metallurgists, even a few years ago. Wireless valves, till recently restricted in use to deal with the small powers in wireless work, were now put to actual service in rectifying alternating currents for smelting purposes. Within a few months it was expected that there would be in Sheffield a small furnace in which this application would be seen. Two years ago such a development was not dreamt of by anyone concerned with the production of the apparatus. In a very short interval of time the electron, formerly regarded as a hypothetical conception existing in the minds of a few physicists and of no possible service in practical industry, had been put to actual application. Nowadays, it was possible to use in the industrial field large valves, conveying as much as 20 h.p. of electrical energy across otherwise empty space, on a stream of electrons. After these and other references to modern developments, Dr. Desch concluded his address by insisting that it was essential for engineers and metallurgists to keep pace with the progress made in pure science.

THE COMMITTEE ON INDUSTRY AND TRADE.

In July, 1924, a committee was set up by the Prime Minister of that time, Mr. Ramsay Macdonald, to enquire into the conditions and prospects of British industry and commerce, with special reference to the export trade. This committee, under the chairmanship of Sir Arthur Balfour, has been asked to continue its labours under the present administration. The task is Herculean, but the committee have entered upon their duties with a determination to achieve something of real value to every type of British industry. Now that the work has reached the stage that plans have been made to deal with the information that will be available, and schemes have been prepared on the way in which the investigations are to be conducted in each industry, it is desirable that attention should be called to the effort. It has been recognised that the publication of a final report on any particular industry is impossible until the activities in associated trades have been dealt with and, therefore, only volumes of a more or less educational character will be prepared from time to time on specific industries as the investigations proceed. No final deductions are to be made in these publications, but the facts elicited in the course of the examination of witnesses will be made available to all as early as is possible. When the deliberations are completed, in the estimated period of two years, reports on the conclusions deduced by the committee will be published. When it is remembered that investigations are to be made into the changes in the world's trade in every class of manufacture, and consideration is to be paid to the means of securing increased British activity, it will be understood that some time must elapse before the amount of information, made available to the committee on any item of their programme, may be summarised. Because of the vital necessity of increased trade in the large staple industries, such as cotton, iron and steel and engineering, it has been decided to obtain evidence relating to them immediately.

PROPOSED ROAD BRIDGE ACROSS THE FORTH.

As one consequence of the reversion to road transport due to the rapid development of motor vehicles, it has become necessary to create first-class roads extending over long distances and coupling up the main centres of population. In travelling by road to the North of Scotland a long detour is necessary from the direct line to get from Edinburgh to the North side of the Forth. In order to avoid this, a road bridge across the river has been suggested by Mr. J. Inglis Ker, who is well known for his early work in the development of motor traction in Scotland as the first editor of *The Motor World*. The scheme was referred to in ENGINEERING of November 9, 1923, when it was originally submitted for consideration. Since then some progress has been made in interesting the Ministry of Transport and the various local authorities in the project, and the time has now been reached when it is necessary to have a comprehensive survey. The Ministry of Transport has decided to defray 75 per cent. of the expenses in connection with this preliminary work. A conference of the various local authorities was held in Edinburgh, on Wednesday, January 21, when objection was taken by the majority of the representatives to the discrimination shown by the Ministry of Transport in dealing with this proposal and with that of the bridge across the Tay, for which the Government are bearing all the preliminary expenses. The scheme is one of great interest, and the proposed bridge is to consist of two central spans of 2,400 ft. length connected to the main roads at each side by approach viaducts. Support for the central pier is to be obtained on Inchgarvie. While there seem to be no engineering difficulties in the proposal and the completion of the structure would afford rapid means of communication between Edinburgh and the industrial parts of the Lothians on the one side of the Forth and the growing towns in Fife on the other, the erection would cost, judging from recent undertakings of a similar character, about 4,000,000*l*. The promoters are satisfied that the advantages to transport are more than commensurate with the probable cost.

WIRE ROPES RESEARCH.

AT a meeting of the North Western branch of the Institution of Mechanical Engineers held on Thursday, January 22, at the Engineers' Club, Manchester, Dr. W. A. Scoble presented the "Second Report of the Wire Ropes Research Committee," which was read in London on December 19, and of which an abstract with a report of the London discussion appeared in our issue of December 26.

Mr. Daniel Adamson, who opened the discussion at Manchester, said he had only lately been appointed Chairman of the Wire Ropes Research Committee, and he was hoping to get some guidance from the meeting for the Committee's future activities. He hoped that they would have some criticisms and suggestions to put forward which would encourage the Committee to proceed, his own view being that they now required to continue the experiments on larger ropes and also ropes of different tensile strengths and ropes with different arrangements of pulleys.

Dealing, then, with the question of one million bend, which meant different things to different users of wire ropes, Mr. Adamson quoted the figures for two 30-ton and one 10-ton cranes in a Manchester engineering shop, which we gave in our report of his speech in London. Another example was two 5-ton cranes with 30,000 lifts per annum, in which the ropes only lasted 18 months, which meant only 45,000 lifts. The average load was only about 2 tons. The sheaves were 21 to 27 diameters of rope. That meant from seven to nine circumferences. A case also was given by Mr. Robert Matthews in a paper before the Manchester Association of Engineers, who had found that he was only getting about 400 to 1,700 lifts per annum with some cranes, and he had recommended 20 to 25 diameters for his barrels and sheaves. At the same time Mr. Adamson had found that in another shop cranes were giving

about 30,000 to 40,000 lifts per annum. That seemed to be about the usual figure for a fully occupied machine shop.

Mr. R. B. Murray said he proposed to confine his remarks more especially to lift ropes. There, however, was an essential difference between the arrangement of loading the rope in the tests and the actual loading in lift practice, where a friction sheave drive was employed. The test pieces, although stressed, were only called upon to turn the rope pulleys against friction, whereas in the case of the vee drive the tractive force was transmitted from the motor through the reduction gear and from the vee sheave to the rope. This tractive force was considerable, averaging in a 10-cwt. lift a tractive force of 560 lbs., transmitted from the vee sheave to the rope by frictional contact. This tended to cause creeping or slight slipping of the ropes in the grooves of the sheave; thus the abrasive wear was heavier than would be the case with the lengths under tests.

In the report it was said that "the cable sometimes stretches at the commencement of a test and again when it begins to break up . . ." This stretching in the first place no doubt was due to the wires and strands forming the rope tending to straighten out. It would be interesting, however, to hear views expressed as to the cause of the second stretching prior to the rope giving out. Was it due to so many wires having broken that the remaining sound wires had become stressed beyond the yield point? It would be of value to know at what stage the second stretching occurred, whether the rope had become dangerous when that stage was reached, or whether there was still a fair margin of useful working life in it. If the latter were the case, then the stage of second stretching might be taken as a practical indication that the rope required renewal.

Lift ropes, as a rule, when put into commission, took up a bedding in the grooves of the pulleys over which they passed, and always presented the same surface to the grooves of the pulleys as in the case of the various ropes tested by the Research Committee, thus wear due to pulley contact occurred over one portion of the rope circumference only, the outer wires in the portion of the circumference became bright and worn, and almost invariably it was those which came into actual contact with the pulleys which broke first. It was generally agreed that, leaving out of the question corrosion or overstress, disintegration of a rope was caused by wear and fatigue. Wear, as stated by the report, might be due either to internal friction of the strands or wires, or to pulley contact.

It was not unusual where ropes made of high tensile steel were used, to find wires in pulley contact broken, and yet showing practically no wear. On the other hand, the wires of ropes made from comparatively mild steel might become half worn through wear in pulley contact and yet show no broken wires. Thus they had indication that reduction of area of the wires did not to any appreciable extent contribute to the fractures. It seemed desirable that the cause of the wires in contact with the pulleys fatiguing more rapidly than the remainder of the wires should be closely examined. If they neglected for the moment the effect of reduction of wires in contact due to wear, exactly why should the wires in contact fatigue and break more quickly than wires adjacent to them, but not actually in contact with the pulley. Each might be said to receive the same amount of bending. Did pressure of the wire on the pulley exactly account for that, or was it not due to the cold rolling effect the pulley had upon the wire in contact, corresponding to the effect of passing a cold bar repeatedly through a rolling mill? If that were so, then the wires in contact became less ductile and thus fatigued more rapidly due to bending.

As an instance that the breaking of pulley contact wires in a rope was not directly proportional to the pressure of the wire on the pulley, the following was an interesting example: A passenger lift was provided with three $\frac{7}{16}$ in. diameter suspension ropes passing from the cage over an overhead vee driving sheave and from thence down to the balance weight, and with a fourth similar rope, but acting as a safety rope, which followed the same lead as the other ropes, passed over the same pulleys, and was anchored to the balance weight at one end and at the other attached to the cage safety gear. This carried no load except that at the cage anchorage it was held in light tension by a spiral spring. Although that rope carried no load it developed broken wires where in contact with the pulley almost at the same rate as the three loaded ropes.

The failure of wires due to nicking and internal breaks was much less frequent in lift ropes than breaking due to pulley contact. That was probably due to the general use of large pulleys and an ample factor of safety. It was interesting to note that lubrication generally reduced the life of a rope. On the other hand, the experience of his company had been that the majority of rope breakages were due to internal corrosion. The surface of the wires of a rope was large as compared with the area. If corrosion commenced, the rope was rapidly weakened, hence the necessity for a lubricant or some other medium to preserve the rope.

The report stated: "The useful life of a rope cannot yet be predicted in general terms from a record of wire breakages." Unfortunately, wire breakage, together with general wear, age and possible distortion, were all the engineer had upon which to form his opinion as to the time when a rope should be discarded, unless the second stage of stretching already referred to might be safely regarded as a practical indication. Where ropes in use were carefully examined and a record of their behaviour was kept, one plan was to count carefully the broken wires in the worst part of a rope over a definite length. These were recorded, the rope periodically examined, and the broken wires counted at each examination. Over a long period, depending upon the amount of work done by the rope, the broken wires increased slowly; later general disintegration set in, and the wire breakages became more rapid. At that point, Mr. Murray said he considered the rope should be discarded.

It would be useful, in connection with ropes of different construction, to know at what distance from a break in a wire the broken wire would again take up its share of the load by frictional contact with its neighbouring wires in the strand. If that distance could be definitely stated for a given rope and it was called D, then the approximate strength of a rope containing broken wires might be obtained as follows:—

"Take a length D in the worst part of the rope. Count all the broken wires in this length. The strength of the rope in its deteriorated condition will then bear the same proportion to its original strength as the existing number of sound wires bears to the total number of wires in the rope, thus:—

$$\frac{\text{Strength of deteriorated rope}}{\text{Original strength of rope}} = \frac{\text{Number of sound wires in length D}}{\text{Total number of wires in rope.}}$$

Mr. C. E. Hill, of the Whitecross Company, of Warrington, said that the wire which had been used for the ropes dealt with in the report stopped at 0·036 diameter, and the carbon of the steel stopped at 0·136. In examining a good many ropes which had failed, he had found it general that with about 0·4 per cent. carbon a structure was formed in use—a hardening at the surface of the rope—which caused the rope to break up very quickly. In much practice the ropes used most frequently were 2-in. circumferences, and there the diameter of the wire necessitated using a higher carbon steel wire than that in the wire which had been used in Dr. Scoble's experiments. In practice they generally had a wire which was brittle. If the same experiments could be carried out on ropes of a much larger circumference, then they could get results which would probably contradict some of the results in the report, but which would be more in line with actual practice of wire ropes. There was one other point in connection with the wearing of the rope around the pulley, and that was concerned with the heat generated at the surface of the wire forming the rope. When high-tensile wire was raised to a temperature of about 200 deg. C. the elastic limit was raised, the tensile strength was raised, but the bending value was decreased in a remarkable way. That would therefore explain the breaking up due to bend of the wires of the rope. It was very interesting to note in the report the stress that had been laid on that bend value. Up till the present, in the manufacture of ropes, a great deal of emphasis had been laid on the torsion tests given by the wire and the tensile strength, but, so far as static tests went, there was really no bend test which could give very much help. What they wanted was a correlation between dynamic tests and static tests.

The apparatus shown in the report was not closely in line with that in a lift. There was no acceleration and no retardation. These were very important factors in the life of a rope, because if the rope got at any time slack and was pulled up, there was going to be very much greater stress placed upon it. One other point was the soft wire core in the second strand. It would be interesting if they could have comparative results between a strand, such as had been used in those experiments, and a similar wire of the same chemical composition, but having a hole after annealing, and giving a strain of 40 to 50 tons per square inch. In practice, he thought it would be found to mean much longer life to the inner wires when those conditions obtained, and it would be interesting to compare that with the strand which had been tried, considering that the soft wire core gave absolutely no advantage.

Mr. E. A. Atkins, referring to the statement in the report that: "The main object of this research is to apply data from which a rope and its conditions of service can be specified so that its performance can be predicted within a reasonable limit," said it was to be hoped that ultimately they would be able to attain to such a condition. He then went on to say that the unfortunate thing in connection with a rope was that the factors which governed its life were so many. After elaborating this point he laid particular weight on the necessity for directing attention to the wire from which the rope was made, as well as to the rope itself. Mr. Atkins' communication followed in the main the lines of that which he contributed to the discussion held in London, on December 19. As that was fully reported in our issue of December 26 last, it is hardly necessary for us to repeat the various details of his arguments here.

Mr. Geoffrey K. Rylands, of Messrs. Rylands Bros., Limited, of Warrington, who was unable to attend the meeting, sent a communication, in which he said that it was noticeable in the report that a good deal more attention was paid to the construction of the rope or strand, than to the quality of the wire. There was no doubt that comparisons could be made between different constructions of strand and rope with the same wire, but it was unwise to compare the same constructions made from different sizes of wire unless it was definitely known that the two sizes of wire in question were of indentically the same steel and in the same condition. They had constantly made tests at Messrs. Rylands, and had found that the only way by which reasonable comparisons of the properties of different sizes of wire under repeated bending tests could be obtained, was to draw the two sizes from the same five-gauge rod, and to subject them to identical reductions in area from the second tempering point, and also to carry out the second tempering under exactly the same conditions of temperature, &c., and, if possible at the same time or at any rate on the same day.

As regards comparisons between different constructions of rope and strand, although the comparisons made in the report were of extreme interest when they were confined to strands involving the one size of wire only, he personally believed that a considerable amount of research work was necessary on the particular quality of wire it was desirable to use for different constructions. Again it might be found that for compound constructions, such as 12 by 6 by 1, it would be more advantageous to use inner wires having rather different properties from the outer wire, for it was evident that the conditions under which the inner wires worked were entirely different from the conditions under which the outer wires worked.

Generally speaking, he felt that there was no knowledge resting on a real scientific basis as to what properties were required in wire for roping purposes. There seemed to be a general consensus of opinion that the wire should stand a large number of torsions, and many people, he was sure, really believed that the greater the number of torsions which the wire would stand, the better its quality. It was difficult to know how that idea had arisen, for evidently the torsional stresses of a wire in a rope were very small, and certainly did not justify the imposition of such an elaborate test. It would appear that in many cases the torsion test was rather overdone, and in the course of years its importance had been exaggerated to a point far beyond the defects in the wire which it was originally intended to detect. That being the case, it must be borne in mind that high torsions might be obtained by the wire manufacturer at the expense of other properties, which would be of far more value in roping wire.

Dr. Scoble, in reply, said that the question of pressure between the pulley and the rope was of great importance. That pressure, he concluded, represented the tensile stress in the rope, or in the present state of knowledge had to be assumed so. It was hardly possible to measure the bending stress correctly, but although it was over-estimated, the calculated stress was appreciably below the elastic limit stress of the material. He had on several occasions emphasised the question of lateral stress due to the pressure of the wire on the pulley. There was no doubt that it did alter the structure of the wire. He had tried to connect up that lateral stress with the tensile and bending stress, and to find a factor for the bending stress and an estimate of the lateral stress. He had found that although he could get a result for one cable, it did not agree with another. But undoubtedly, even if they left out of account any alteration in structure, if they had a wire under tension and they subjected that to a lateral pressure, that would alter the stress appreciably in the material, and also the value of the tensile stress which would cause failure. That was a point the importance of which he had drawn attention to in the original report. Perhaps it was not more emphasised in the present report because, unfortunately, they had not got to the bottom of the question yet.

One or two speakers had spoken about hard and soft wires. He had started out with wire of about 85 tons per square inch, and now he had cables in hand in which the wire had a tensile strength of 105 tons per square inch. As regards the amount of wear and fracture,

that depended rather on the conditions. For example, if a large pulley were used, so that the cable even for a definite number of bends would take a high tension, there would be much more wear than there would be if the same cable were used on a smaller pulley. The smaller pulley might cause the cable to break at a lower tension, but there would not be nearly so much outside wear. With regard to his statement about lubrication reducing the life of a rope, Dr. Scoble said that lubrication was not put on entirely to increase endurance. The general attitude taken up was that the wire rope was lubricated to reduce the friction between the wires and the friction between the strands. That was emphasised more than the protection of the cable from corrosion. His reference to the question of lubricating was intended to have a bearing on what the stuff put on was intended to do.

Mr. Hill had raised a number of interesting points, and in speaking of the carbon contents of the steel, Dr. Scoble thought he had already shown that they were dealing with that one particular quality, because they wished to limit their variables. But they were following on with other work. They had in hand at the moment some ropes of 105 tons per square inch, and while they had started with small ropes they now had in hand 2-in. ropes. It was no good trying to run before they could walk! The torsion test had been referred to by two or three speakers. In the days when he started with wire ropes, in association with Dr. Morley, the thing that had struck him was that nobody seemed to be quite sure what the torsion test was for. It was a common thing for people to say that the torsion test indicated the ductility of the wire. As a matter of fact, the ductility of the wire had nothing to do with it. They had purposely avoided introducing the question of acceleration and retardation, so as not to complicate the tests, but he quite realised its importance.

THE LATE MR. H. D. ELLIS.

WE note with regret the death of Mr. Henry Disney Ellis, which occurred at his brother-in-law's residence, Alvechurch, Worcestershire, on Sunday, January 25. Mr. Ellis, who did much constructional work for the railways of Canada, was Commissioner of Public Works and Surveys to H.H. the Rajah of Sarawak, and later devoted himself to the manufacture of products in non-ferrous alloys at home, was in his 71st year.

He was the son of Colonel H. D. Ellis, and at the age of 18 years went to Canada, where he obtained a good engineering training in general works and in railway service. After two years' experience as Assistant Engineer on the Ontario and Sault Ste. Marie Railway, he was appointed to conduct railway surveys for the Canadian Government, and on the completion of this work he was appointed Assistant Engineer on the Northern Pacific Junction Railway. While in this position he located the line from Gravenhurst to South River. He was then transferred to the Chief Engineer's office for constructional work, and remained there until 1885, when he joined General Middleton's forces as a lieutenant in the Intelligence Corps during the North-West Rebellion. On returning to Toronto, Mr. Ellis was appointed engineer in charge of adjustment of track for over 200 miles of railway. In the year 1888 he went into the service of the Canadian Pacific Railway on the Detroit extension of the Ontario and Quebec branch, and two years later undertook harbour construction work at Toronto, under Mr. W. T. Jennings, M.Inst.C.E. His next appointment was to take charge of roadways in Toronto, which he received in 1890, and in this position he constructed some 80 miles of electric tramway lines. From here he proceeded to Manitoba to act as Engineer for Messrs. Mackenzie, Mann and Co., the contractors for the Manitoba and Lake Dauphin Railway. The next year, 1897, he commenced his work in Sarawak, and was for ten years in the service of the Rajah's Government.

Since 1910 Mr. Ellis had been associated with the alloys department of Messrs. Callender's Cable and Construction Company, Limited, and rendered good service in connection with the production of alloys for quick-firing shell cases and other munitions during the European War.

PERSONAL.—The Journal of Scientific Instruments, a monthly publication, produced by the Institute of Physics with the co-operation of the National Physical Laboratory and hitherto published by the Institute, will in future be published by the Cambridge University Press on behalf of the Institute.—It is announced that Sir W. G. Armstrong, Whitworth and Co., Limited, have acquired from the Receiver for the Boving Engineering Company, Limited, the goodwill, plans, patterns, &c., of the Boving pump. In future Boving pumps will be manufactured solely by Sir W. G. Armstrong, Whitworth and Co., Limited, to whom all inquiries regarding new pumps, replacements or repairs should be addressed.

LAUNCH OF THE STEAMER "NEWFOUNDLAND."

ON Saturday last, the 24th inst., the single-screw steamer Newfoundland, for the Warren Line (Liverpool), Limited, was successfully launched from the Barrow-in-Furness yard of Messrs. Vickers Limited. The vessel, which is intended for passenger and cargo service between Liverpool and Newfoundland, has an overall length of 423 ft., a moulded breadth of 55 ft. 3 in., a moulded depth to upper deck of 34 ft. 4 in. and a gross tonnage of 6,820, while her draught at a deadweight of 6,500 tons will be 25 ft. 3 in. The Newfoundland has been built with a straight stem and a cruiser stern, and has three complete decks, in addition to bridge, forecastle, and boat decks. Accommodation will be provided for 100 first-class and 80 third-class passengers, the crew carried numbering 100. The holds and 'tween-deck spaces throughout the vessel are specially arranged for carrying grain, and two of the 'tween decks are insulated. The vessel will be propelled by one set of four-cylinder quadruple-expansion engines, constructed by the shipbuilders, and capable of developing 5,560 i.h.p. at 80 r.p.m. Steam will be supplied at 215 lb. per square inch by five single-ended cylindrical boilers, 16 ft. 9 in. in internal diameter and 12 ft. in length, each having four Deighton furnaces. The total heating surface will be 16,400 sq. ft., and the total grate area 377 sq. ft. The boilers are arranged to burn either coal or oil with Howden's forced-draught and smoke-tube type superheaters will be fitted to give a superheat of 100 deg. F. The vessel has been constructed under Lloyd's supervision, and is classed 100 A1 in accordance with the 1923–24 Rules. The whole of the machinery will comply with the requirements of Lloyd's and the Board of Trade.

YEAR-BOOKS AND ANNUALS.

Social and Other Clubs.—We have received a copy of the thirty-third annual edition of "Clubs" for the year 1925, edited by Mr. E. C. Austin-Leigh, and published by Messrs. Spottiswoode, Ballantyne and Co., Limited, of New-street Square, London, at a price of 7*s.* 6*d.* net. This book contains a list of 3,950 clubs frequented by British people all over the world, and supplies, in tabular form, particulars relating to each of these establishments. The names of the different clubs are grouped under three headings, according as to whether they are London, provincial, or foreign, and the value of the provincial group for purposes of reference is much enhanced by the inclusion of a comprehensive index. Business men should find the book helpful in locating persons promptly and conveniently.

Year Book of Scientific and Learned Societies.—This useful publication, which has now reached its 41st year of issue, gives particulars of practically all the societies and government institutions in Great Britain and Ireland that are connected with the various aspects of science, literature and art. The societies are classified in sections according to the subjects dealt with, the name and address of each society being followed by a list of officers, particulars of meeting places and member ship, a list of publications and of papers read and discussed during the 1923–24 session. This list constitutes a valuable record of intellectual activities of the nation throughout the period covered, and the complete work forms a most useful reference book for those requiring information on matters connected with scientific, literary and artistic organisations. The book is published by Messrs. Charles Griffin and Co., Limited, Exeter Street, Strand, London, W.C. 2, and its price is 15*s.* net.

South and East African Year Book and Guide.—A useful gazetteer for the office desk, a volume full of concise and practical information for the settler, and an invaluable handbook and guide for the traveller, the "South and East African Year Book and Guide" serves many wants. This is a work prepared by Messrs. A. Samler Brown and G. Gordon Brown for the Union Castle Mail Steamship Company, Limited, and published by Messrs. Samson Low, Marston & Co., Limited, London, at 5*s.* net. A great quantity of information is given in it on the imports and exports of the various sections of the territory, and useful hints are given regarding the markets. In this respect the new edition seems to be even better than the earlier ones, for every care has been taken to bring the notes up to date. Statistics on trade conditions, and other matters of importance to merchants, are available in almost every section of the work. Accurate statements on through routes and other railway connections enhance the value of the book to the traveller, while the descriptions of the towns, their outstanding features, and their industries are very complete. Whatever questions the tourist cares to ask about anything between Capetown and Port Said, and between Angolaland and Zanzibar, is answered somewhere in the volume. A specially prepared atlas of 64 pages of maps in colour replaces the old folding map and this can only be regarded as a very serviceable improvement.

Directory of Shipowners, Shipbuilders and Marine Engineers, 1925.—This directory, now in its twenty-third year of publication, is a very handy desk companion, which has been compiled under the direction of the Editor of "The Shipbuilding and Shipping Record." By its use information may be obtained immediately as to the ownership of any specific vessel, who built the ship and who constructed the engines, what are the tonnage, the draught and other features as well as the year of its going into commission. In addition to this service, the directory fulfils the requirements of those who desire statements of the capacities of the various shipyards and the names of the directors and leading officials of all the shipowning and shipbuilding companies. Information is also given relating to the personnel of the Government Departments which have associations with the industries concerned, as well as of the classification societies. A supplementary section includes a list of trade and technical organisations, and a directory of consulting marine engineers and naval architects. A pleasing feature, to any who view the book in the light of making the information it contains immediately available to the user, is the thoroughness with which the indexing has been done. This very valuable work is a product of the Directory Publishing Company, Limited, of 33, Tothill-street, Westminster, S.W.1, and is sold at 20*s.* net.

The Textile Recorder Year Book, 1925.—Amongst the many year books on the technical industries of the country, one of considerable importance is "The Textile Recorder Year Book." It is not merely a collection of tabulated data but contains articles on all phases of the industry, which give evidence of the present-day outlook on development. For this highly creditable work Mr. Frank Nasmith is responsible, and it is published at 7*s.* 6*d.* by Messrs. John Heywood, Ltd., Deansgate, Manchester. The information it contains is regularly kept abreast of the progress made, by the annual revision of the various sections by expert authorities. In addition to the purely textile work, information is provided on the dimensions of machines, their characteristics and outputs and the means of getting over any difficulties experienced in their running. There is an engineering section in the volume, dealing with fuel combustion, boilers, engines, electric generators and motors, transmission gearing, millwrighting and many other matters of importance to those designing and equipping cotton factories or keeping the plant in efficient running condition. Humidifying, lighting and other matters, which mean much in the obtaining of efficiency, are not neglected. There are also provided articles on patents, new companies and the conditions of labour in the industry in various countries of the world.

Almanacs and Calendars.—We have received monthly tear-off calendars from Messrs. Royce, Limited, engineers, of Trafford Park, Manchester; Messrs. Crofts (Engineers), Limited, of Bradford, Messrs. R. Y. Pickering and Co., Limited, engineers, of Wishaw, Scotland; Messrs. J. Shaw, Sons, and Greenhalgh, engineers, of Albert Works, Huddersfield; and Messrs. William Brown and Co., Limited, lithographers of 2, Bury Court, St. Mary Axe, London, E.C. That sent by the latter firm is a handsome reproduction of "The Old Curiosity Shop," after the original pencil drawing by Joseph Pike, exhibited at the Royal Academy in 1924.

UNIVERSITY COLLEGE, LONDON, ENGINEERING SOCIETY.—The annual dinner of the Engineering Society of University College, University of London, was held in the College Refectory on Monday, the 26th, and proved a most successful function. The chairman on the occasion was Sir Alexander Kennedy, whose connection with the Engineering Department of the College, in its early days, is too well known for it to be necessary for us to enlarge upon it. Sir Alexander, we believe, holds the record of having attended every dinner since the formation of the society during his professorship. The founder, Mr. E. C. de Segundo, was also present, and the attendance was larger than at any previous event of the kind, the assemblage numbering 175 old members, guests, and present members. The toasts included "University College," proposed by Dr. W. B. Worthington and replied to by Sir Gregory Foster. "The Guests" was proposed by Mr. de Segundo and replied to by Professor A. V. Hill. These and other speeches during the evening were of a most entertaining nature, and the evening proved a successful and thoroughly enjoyable one. At the conclusion a conversazione was held in the Engineering wing and interesting demonstrations were given. The programme included a lecture by Sir Ernest Moir on the development of the department. The function reflected great credit upon Professor E. G. Coker and his staff.

PETROL-DRIVEN CONVERTIBLE EXCAVATOR

CONSTRUCTED BY THE NORTHWEST ENGINEERING COMPANY, ENGINEERS, CHICAGO, ILL., U.S.A.

FIG. 1.

THE NORTHWEST CONVERTIBLE SHOVEL.

IN order to reduce capital invested in plant, contractors in particular branches of work are naturally anxious to keep the machines they possess in service as continuously as possible. With this object, manufacturers of certain types of plant have devised machines which are to a certain extent convertible. This has been accomplished by both British and American firms. As an interesting example of the degree of convertibility attained in one instance in the latter country, we may cite the machines produced by the Northwest Engineering Company, of 28, E. Jackson-boulevard, Chicago, Ill., the illustration, Fig. 1, annexed, showing a range of five machines quickly convertible to any one of these forms, the fundamental type being the shovel shown in the foreground of this illustration and again in Fig. 2.

This shovel is driven by a gasoline (petrol) engine, one engine only being used for all motions, and the only modification in the event of conversion relating to the class of jib or boom adopted. Taken in order behind the shovel, in Fig. 1, there stands first a long jib crane fitted with a grab-bucket. Next to this machine stands the trench "pull-shovel," of which we gave a description in our issue of April 25 last (page 519). Beyond this stands a drag-line machine, and still further is an example of this unit fitted up as a portable pile-driver. In all these the main parts are similar, the track units, revolving platforms and the engines are identical. Further, in three of the modifications, the jib structures are similar. Thus, a contractor, by purchasing spare jib equipment to meet his requirements can turn the one machine on to a variety of jobs, and make better use of his capital investment; the change in most cases occupies only about three hours or so.

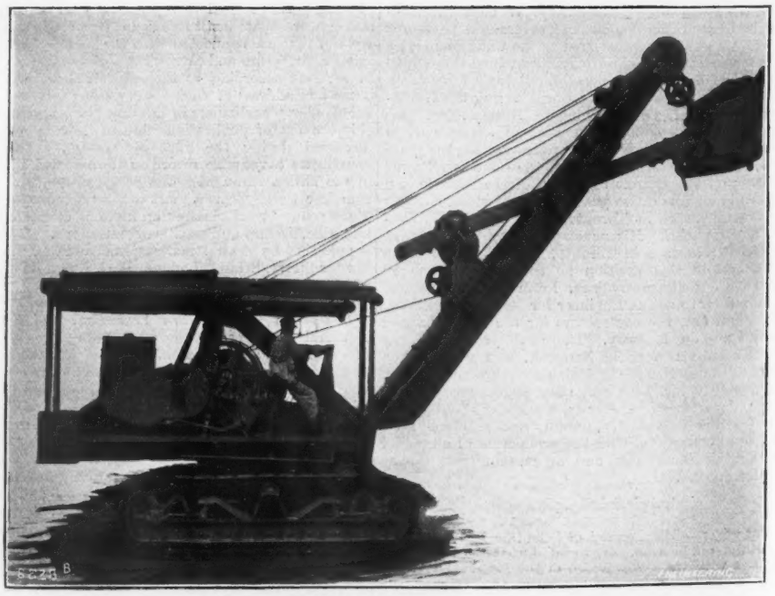

FIG. 2.

In Figs. 3 to 10, on page 147, we illustrate some of the features of these machines. Figs. 3 to 6 relate specifically to the shovel, and illustrate the manner in which a complicated action is secured by means of a simple main drive which can be made to serve satisfactorily for the other modifications. In this gear the main winding drum is composed of two barrels, loose on a single driving shaft, and clutched in as required. Fig. 5 indicates the two drums, on to which separate ropes are wound, rope B running on to the left drum, and rope C on to the right. At the top of the jib is a compound drum of two different

PETROL-DRIVEN CONVERTIBLE EXCAVATOR

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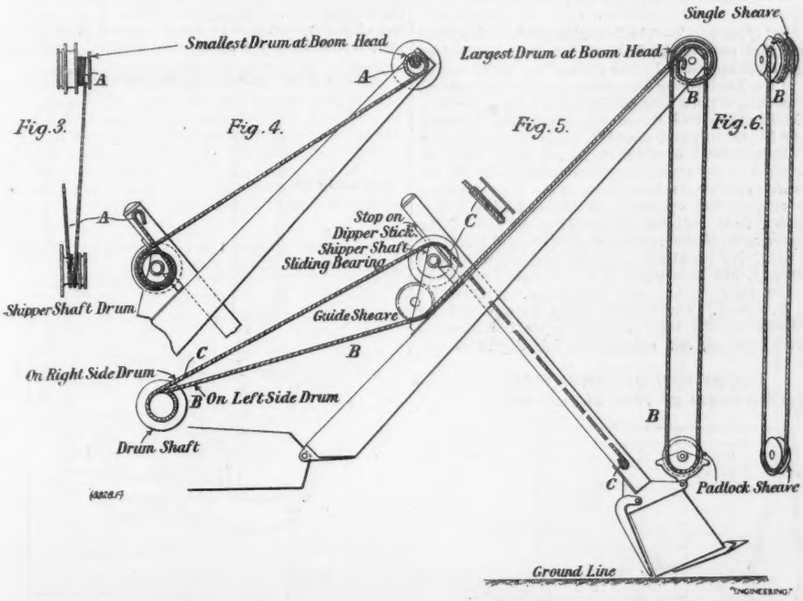


FIG. 7.

FIG. 8.

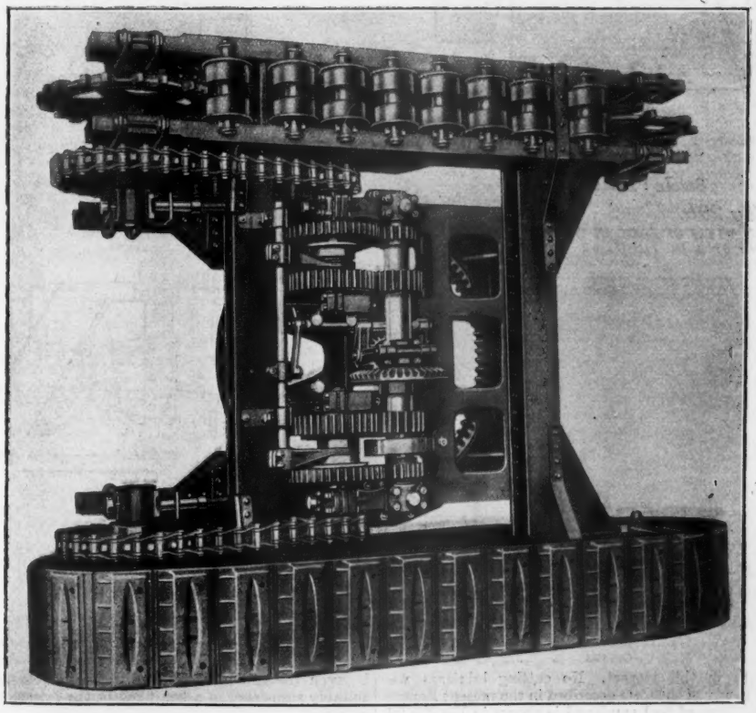


FIG. 10.

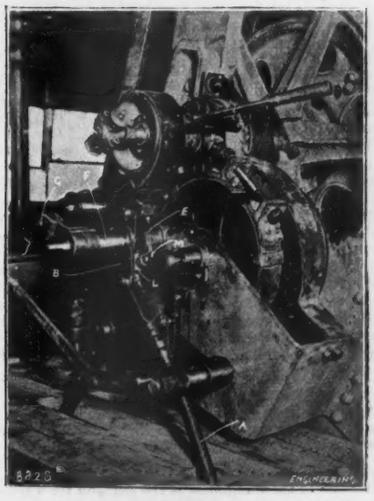


FIG. 9.

diameters, and a single grooved pulley. The hoisting rope B is carried over the latter, down to a single sheave on the shovel bucket, and up again to the jib head, where it is coiled round and made fast to the large diameter drum. Referring now to Figs. 3 and 4, it will be noticed that coiled round and fastened to the smaller drum at the jib head is a second rope A, which is led down to a drum on a bracket carrying the bucket boom or "dipper stick," as it is termed in America. After a couple of turns round this drum, this rope is led off and fastened to the inboard end of the bucket boom, as will be seen in Fig. 4. On the same axis as this lower drum is a single-grooved pulley over which the rope C is carried from the right side main drum to the outboard end of the bucket boom. The action is as follows: Assuming for the moment that the rope C is held fixed by the right-hand drum brake, if B be wound in, the bucket is hoisted simply. If the shovel lip digs into the bank, and the brake on C be slightly relieved, the resistance offered by the digging operation will result in sufficient tension on the hoisting rope to cause it to unwind off the large drum at the jib head. This drum in revolving winds in on the small barrel the rope A attached to the bucket boom, with the result that the boom is forced outwards, the thrust for digging being thus obtained without any direct engine drive for this gear. The rope C is paid out as required, while,

if it is necessary to draw the bucket out of the bank to relieve the load, this is effected by hauling in this rope.

The main drums are engaged by clutches operated by the Northwest system of "feather touch" control. The clutches are positively disengaged, and only a very slight effort is requisite to engage them. The control as fitted to the right hand drum is shown in Figs. 7 to 9. Of these Fig. 7 shows the gear, with, however, a guard surrounding a small clutch. This somewhat confuses the arrangement, which is shown, with certain parts removed, rather more clearly in Figs. 8 and 9. The control levers are on the right front of the revolving platform, conveniently ahead of the operator's position as shown in Fig. 2. Operation of the right drum control lever either pushes up or pulls down the rod marked A, Fig. 9. To engage the drum clutch this rod is pushed up, throwing over the small lever B. This puts a slight tension on the friction band immediately above. The result of this is a considerable pull on the end D of this band, which pulls over the lever arm E. This arm and an outer arm G are both keyed to one shaft and a movement of E results in a corresponding movement of G. The latter is fitted with a link J, above which is a bell crank K (Fig. 7) having two arms with jaws. These two parts are removed in Figs. 8 and 9, in order to show more clearly the end of a rod H, Fig. 8, which runs inside the main driving shaft, and operates the drum clutch. This rod has at its outer end a cross head with rollers fitting into the jaws of the bell crank referred to above. Movement of the arm G, transmitted through the bell crank pushes in this rod, causing the main clutch to engage. If the control lever be pushed away by the operator, the rod A is pulled downwards. The lever B is pulled back and a lug L (Fig. 9) comes up against an adjustable set screw on E and pushes this in a direction opposite to that previously mentioned. This movement is transmitted to the lever G and, through the link and bell crank, the rod H is pulled outwards, the main clutch disengaging as a result. The actual lever effort is magnified greatly by the action of the friction band, and the control is said to be sensitive to a slight touch either way.

The one engine on these machines is of 60 h.p. for the ¾ cubic yard machine and 70 h.p. for the 1 cubic yard machine. The former runs at 565 r.p.m. and the latter at 500 r.p.m. The 70-h.p. engine has four cylinders, 7¼ in. by 9 in. stroke, and overhead valves. The drive from the engine to the main shaft is through wide helical gears mounted on ball bearings. From the main shaft the drive is transmitted to the drum shaft, or through clutches and reversing bevels to the chain-track drive, and slewing motion. The chain-track unit is illustrated in Fig. 10, which shows the underside of the base with one chain track removed. The drive is brought to a vertical shaft in the centre of the base, a bevel on the end of it gearing with the bevel shown on the cross shaft to be seen in Fig. 10. This shaft is fitted with gears in mesh with others on two short shafts fitted with clutches. On the ends of these latter shafts are sprockets driving by chain large sprockets on the ends of the track frames. The chain tracks are supported by a number of rollers. The tracks are under control the whole time and manœuvring is accomplished by slowing down instead of completely stopping one or the other of the tracks, or, if necessary, in conjunction with reversing. A single lever controls the steering, whose action is independent of the relative positions of the platform and base.

The whole construction of these machines is exceptionally rugged. The gears are all of liberal width and bearing surfaces are ample. Heavy type ball bearings are used for all shafts running at more than 45 r.p.m.; chrome-nickel and nickel steel enter largely into the working parts; splines are used instead of keys, and many other features adopted with a view to ensuring long service and freedom from breakdown. The base is very substantially built with a heavy steel centre casting.

The "gasoline"-driven machine has become very popular in the United States owing to the ease of transport of petrol and the advantages derived from being able to start the machine quickly on its work without firing and stand-by losses and waste time. Labour is also reduced, these machines being operated by one man only. A machine of the Northwest type can load itself on to an ordinary flat railroad car, and on arrival at destination can move itself off the car at once and travel under its own power to its job. The particular design which we have described above is characterised by greater simplicity than is often common, the single engine and unique drive greatly contributing to this.

INDUSTRIAL DEVELOPMENT.—In strong contrast to the industrial uncertainty prevailing throughout the country a year ago, many inquiries are being received at present for factories, wharves, warehouses and land by those who are in a position to dispose of such premises. A feature of these inquiries is the demand for waterside properties, and this is probably due to the desire to take advantage of this facility to cheapen production costs.

CUTTING TOOLS RESEARCH.

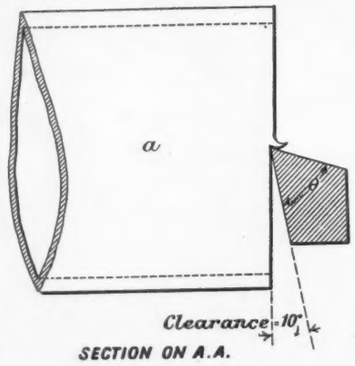
*Report on an Experimental Study of the Forces Exerted on the Surface of a Cutting Tool.**

By T. E. STANTON, C.B.E., D.Sc., F.R.S., and J. H. HYDE.

Object of the Work.—The investigation here described forms that part of the National Physical Laboratory programme approved by the Committee, to be carried out in the Engineering Department of the Laboratory. The cutting actions here considered are those due to a perfectly sharp tool before any appreciable blunting action has taken place, attention being concentrated on the characteristics of the material cut rather than as heretofore on the material of the cutting tool. All the present experiments have been made with a simple side cutting tool operating on the end of a hollow cylinder, thus reducing the problem to one of the measurement of the vertical and horizontal forces on the tool. No variation, either in composition or heat treatment, has been made in the tool steel employed for the tests, which was Armstrong, Whitworth's "A.W." steel. The finished tools were tested for hardness, on the top-rake surface by the diamond scratch method, and exhibited a fair degree of uniformity in this respect. No cutting lubricant was used in any of the tests described in the present Report.

LATHE TOOL DYNAMOMETER.

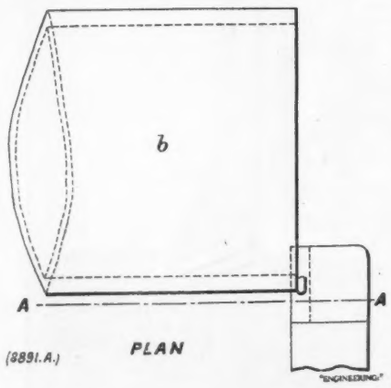
Fig. 29a. FORM OF TOOL EMPLOYED.



SECTION ON A.A.

Scale: Full Size

Fig. 29b.
PLAN VIEW OF TOOL IN OPERATION AGAINST THE END OF TUBULAR WORK.



PLAN

The form of tool employed is shown in Fig. 29 (*a*), the section being taken perpendicular to the cutting edge, and parallel to the axis of the tubular work operated upon. In the form of the tool the only variable was the cutting angle θ; the clearance angle being constant and equal to 10 deg. A plan view of the tool in operation is shown in Fig. 29 (*b*), the material having been previously machined to an inside diameter of 1·625 in. and a thickness of 0·10 in. The tube was held on a suitable arbor, one end of which was gripped in the chuck of the lathe and the other supported in the usual manner by the tail stock.

Dynamometer.—The dynamometer was specially designed for the purpose of the work by Mr. Hyde, and was constructed in the Engineering Workshop. The general principles of the design are shown in Fig. 30. The toolholder A, which grips the specimen of tool steel in the manner common in lathe tool-holders, rests on a horizontal knife-edge B, extending the full width of the holder and placed on the underside of it near to the cutting tool. Upward movement of the opposite end of the holder, due to the downward force on the tool, is resisted by a short steel strut C, interposed between the end of the holder, and a diaphragm D, suitably supported in a box fixed to the dynamometer casing.

Fig. 30a. GENERAL ARRANGEMENT.

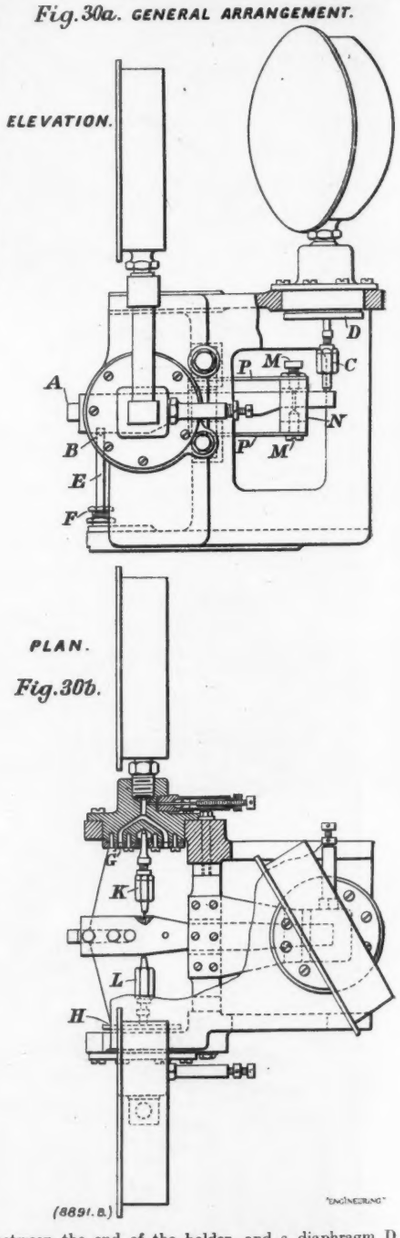


Fig. 30b.

The strut C is provided with hardened pointed ends which bear in hardened recesses in the holder and diaphragm plate respectively, and it is also adjustable in length. The knife-edge support E, near the front of the tool-holder, is formed on the upper end of a second strut. This strut bears at its lower end, on a hardened steel ball retained at the bottom of a short cylindrical guide F, fixed to the casing of the apparatus, and the strut near the end is formed partly spherical, so that it is capable of slight rolling motion in the guide. The guide F is adjustable vertically to enable the tool edge to be levelled with the lathe centre. This arrangement of support allows slight movement of the tool-holder sideways, at the same time providing that the knife-edge is bearing along the whole length of its knife-edge plate. The long knife-edge reduces the tendency for the tool-holder to rotate.

Side movement of the tool-holder is resisted by two

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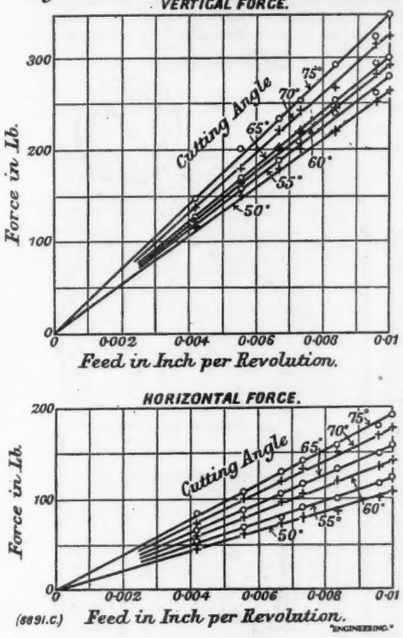
* Presented at a meeting of the Institution of Mechanical Engineers on Friday, January 23, 1925. Abridged.

diaphragms C and H and struts K and L, as shown in the plan view of Fig. 30. These struts and diaphragms are exactly similar to those shown at D and C respectively. When the apparatus is in use, the sidestruts are adjusted in length until the pressure-gauges which are in communication with the side diaphragm boxes read about one-half their maximum values, in this case indicating equal and opposite side forces of about 600 lb.

The tool-holder is further supported by a vertical pivot consisting of two pivot-screws, M,M, fixed to a block N, through which the tool-holder passes. The block N is supported in turn by two parallel and horizontal thin steel spring plates P.P, secured to the casing as shown in Fig. 30. These plates, together with the pivot, oppose motion of the tool-holder in a horizontal plane, but allow it freedom to rotate about the axis of the pivot, and freedom to move in a vertical plane. The resistance to bending of the plates is very small for the very slight movement required, but it is included in the calibration for vertical force. Oil is used as the hydraulic medium, and great care is taken to ensure that air is not trapped in the diaphragm boxes and the pressure tubes of the Bourdon gauges communicating with them. Provision for adjustment of the zeros of the pressure gauges is made by the employment of small screw pistons working in cylinders communicating with the diaphragm boxes.

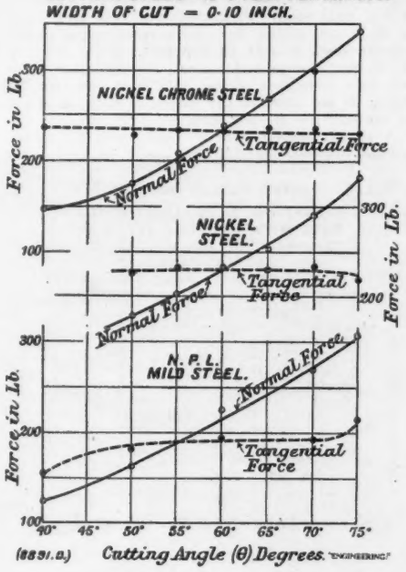
Fig. 31. LATHE TOOL DYNAMOMETER. NICKEL STEEL.



No. 1, nickel steel. It will be seen that for each value of the cutting angle, ranging from 50 deg. to 75 deg. in steps of 5 deg., the plotted points correlating the horizontal or vertical forces on the tool with the traverse, lie approximately in straight lines through the origin. This characteristic is common to all the materials tested except in the case of copper, in which the forces did not increase in direct proportion to the feed, the ratio of force to feed being less at the higher values of the latter.

The forces normal and perpendicular to the top rake surface for materials Nos. 1, 2 and 3 are shown in Fig. 32. From inspection it will be seen that the essential characteristics of the curves for these materials are broadly similar in that :—

Fig. 32. LATHE TOOL DYNAMOMETER. CURVES SHOWING VARIATION WITH CUTTING ANGLE OF FORCES NORMAL AND TANGENTIAL TO TOP RAKE SURFACE, FOR NICKEL CHROME STEEL, NICKEL STEEL, AND N.P.L. MILD STEEL.



(1) The component of the force parallel to the top-rake surface is roughly independent of cutting angle, except for small values of this angle.

(2) The variation in the force normal to the top face falls rapidly at a constant rate as the cutting angle diminishes from 75 deg., but in the case of all the steels which have been tested there appears to be definite evidence that this normal component tends to a limiting value in the lower part of the range of cutting angle.

The curves for cast iron, copper and brass show a small but appreciable reduction in the tangential forces as the cutting angle is reduced.

The Frictional and Abrasive Forces in the Cutting Action.—Before attempting any analysis of the resultant forces on the tool along and perpendicular to the top-rake surface, the conditions under which the chip is removed may be reviewed. In Fig. 35 (*a*) let OB be the top-rake surface of the tool, making an angle ϕ with the direction of motion, and OA the trace of the plane of shearing of the chip, making an angle a with the direction of motion. It is commonly assumed that a is sensibly constant for ordinary materials. It will be convenient in the first place to consider the cutting action as consisting of the following two operations : (*a*) An indentation by the nose of the tool to a depth OO′ such that shearing along O′A′ parallel to OA eventually takes place. (*b*) By sliding of the material of the chip along O′A′, giving rise to internal friction which may result in complete detachment from the stock in the case of large cutting angles, or in partial detachment with bending in the unsheared portion accompanied by sliding over the top-rake surface of the tool.

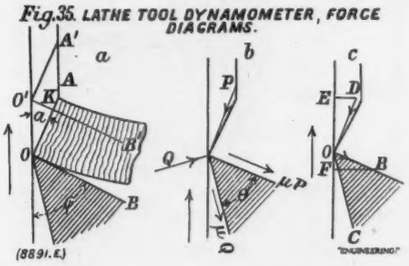
As regards the action under (*a*), experiments at the National Physical Laboratory have shown that, within limits, in the indentation of a metal by tools of widely different shapes : (1) the intensity of the pressure normal to the surface of the indentation may be regarded as a constant for the material, and (2) the tangential pressure on the surface bears a fixed ratio to the normal pressure. It would appear, therefore, a legitimate assumption to consider the normal and tangential intensities of pressure produced by the indenting forces of the tool as independent of the cutting angle.

On the other hand, the forces required to overcome the internal friction of the material of the chip described under (*b*) would appear to be largely dependent on the value of the cutting angle, and to be relatively small when the material comes away in the form of a continuous ribbon showing little permanent deformation.

These considerations have led to the assumption that in the lower region of the range of cutting angle the internal friction and bending forces considered under (2) are small compared with the indenting forces, so that the observed pressures may, with sufficient accuracy for the purpose, be used for the calculation of the indenting forces.

On this assumption the forces system could be represented as in Fig. 35 (*b*), P, Q being the normal forces on the top-rake and side clearance faces respectively and μ P, μ Q the frictional forces. For any cutting angle θ at which the resultant forces perpendicular and along the top-rake surface taken from Fig. 32 were a, γb, we have—

Fig. 35. LATHE TOOL DYNAMOMETER, FORCE DIAGRAMS.



$$\left.\begin{aligned} P + \mu Q \sin\theta - Q\cos\theta &= a \\ \mu P + \mu Q\cos\theta + Q\sin\theta &= b \end{aligned}\right\} \quad . \quad . \quad (1)$$

from which P and Q can be found when μ is known.

From experiments at the National Physical Laboratory, it would appear that μ can be taken to be 0·35. Assuming this value for μ, the values of P and Q for the materials of Fig. 32 have been calculated. From the data thus obtained, it is possible to plot curves showing the forces, due to indentation only, for all values of the tool angle, in the following manner.

Referring to Fig. 35 (*a*), if O′K be the amount of the indentation of the tool before shearing commences, then—

$$O'K = OO'\frac{\sin a}{\sin(a+\phi)}.$$

It is clear, therefore, that since the intensities of normal pressure due to indentation remain constant for different cutting angles, the values of P, the total normal forces, will be proportional to the values of O′K, that is, to—

$$\frac{\sin a}{\sin(a+\phi)}$$

It follows, therefore, that if P_1 be the value of P at a cutting angle θ_1, the value at a cutting angle θ_2 will be given by—

$$P_2 = \frac{\sin(a+\phi_1)}{\sin(a+\phi_2)}P_2.$$

Since a is approximately 26 deg. it will be seen that between values of the cutting angle from 50 deg. to 75 deg., which is the range in the present experiments, the values of P are nearly constant.

As regards Q, since the clearance angle remains constant, the natural assumption is to regard its value as independent of the changes in cutting angle.

No. of Material.	Test Mark.	Material.	Analysis. C.	Si.	Mn.	Ni.	Cr.	Va.	Tensile Test. Yield.	Ult.	Extension. G.L. = 4x Area.	Brinell Hardness No.
									Tons per Sq. In.	Tons per Sq. In.	Per cent.	
1	AEG1.	Nickel Steel.	0·36	0·19	0·425	3·43	0·21	—	35·7	48·8	23	202
2	BNW.	Nickel Chromium Steel.	0·33	0·18	0·485	3·41	0·53	—	55·5	62·7	16	275
3	BBJ.	Mild Steel (NP).	0·22	0·06	0·680	—	—	—	17·2	29·4	38	130
4	BNX1.	Hydraulic Tube, as drawn.	0·49	—	0·80	—	Nil	Nil	34·8*	41·0	17	183
5	BNX2.	Hydraulic Tube, Annealed.	0·49	—	0·80	—	Nil	Nil	29·2*	40·2	29	165
6	BPN.	M. S. Bar.	0·47	0·15	0·91	0·18	0	—	26·8	48·6	23	214
7	BRK.	Cast-Iron.	3·2 (2·7 Graphite 0·5 Combined)	2·0	0·57	—	—	—	—	—	—	209
8	BRL.	Brass.	Copper 61·8. Lead 0·43. Tin 1·20 Zinc 36·47.					—	—	—	—	104
9	BOE.	Copper.						—	—	—	—	83

* No. 4.—The hydraulic tube was chosen for the reason that, when tested in the state in which it was received, it was found to possess quite abnormal cutting characteristics compared with the other materials. For the purpose of comparison No. 6, of approximately the same composition as the hydraulic tube, was kindly supplied by Dr. W. H. Hatfield, of the Brown-Firth Research Laboratories, Sheffield.

Materials Used.—The materials on which cutting tests were made, with the results of their analyses, mechanical properties, and Brinell hardness, are given in the Table above.

Results of the Tests.—The results of a typical series of observations made at a given cutting speed and depth of cut, the variables being cutting angle and traverse, are shown plotted in Fig. 31, for the case of material

In any case, the variation is not likely to be appreciable.

Inserting the values P and Q in equation (1), the values *a* and *b*, for indentation only, can be calculated for different values of the cutting angle. Comparative curves can then be plotted showing the observed resultant normal and tangential components, and also the calculated components of indenting forces. The difference of the ordinates for any given value of the cutting angle may be taken to represent roughly the magnitude of the forces due to the internal friction of the metal of the shaving, and in the authors' opinion this effect must be regarded primarily as the cause of the loss of work incurred by the use of large cutting angles.

The question of the friction of the shaving on the top-rake surface of the tool has been discussed by Mallock. Ignoring the actions on the clearance face of the tool, Mallock considers that the essential condition to be fulfilled is that the friction on the tool face should balance the inward components of the

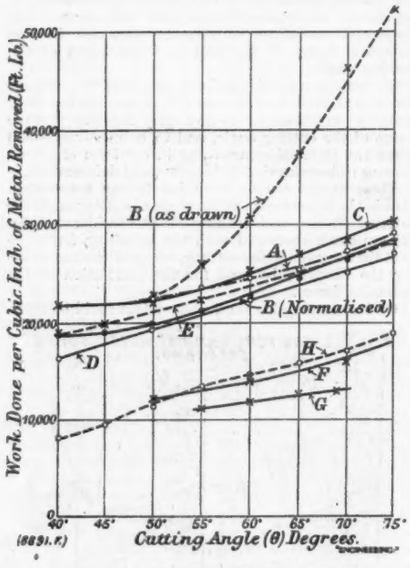


FIG 37.—*Lathe Tool Dynamometer.*

Variation with Cutting Angle of the Work done per Cubic Inch of Metal Removed.

		Inch.
Feed = 0·01 in. Width of Cut.	Nickel steel	0·10 (A)
	Hydraulic tube	0·10 (B)
	Nickel chrome steel	0·10 (C)
	N.P.L. mild steel	0·10 (D)
	Mild steel	0·10 (E)
	Cast iron	0·10 (F)
	Brass	0·25 (G)
	Copper	0·20 (H)

force due to its slope, so that there is no tendency either for the tool to "dig" or to retreat from the stock. Thus in Fig. 35 (c) if DO represent the component of the resultant force on the tool normal to the top-rake surface, and OB the component tangential to it, then DE represents the "digging" force and FB the force pulling the tool from the work, and the condition of least work done in removing the shaving is obviously that FB should only exceed DE by an amount necessary to secure stability in the thickness of the cut. Unfortunately this condition is not practicable with the majority of materials, for the reason that it demands cutting angles so small that the tool is worthless from the point of view of endurance.

Thus with the nine materials used in the present experiments at the smallest cutting angles at which tests could be made without immediate blunting of the tool, the ratios of the horizontal force to the vertical force were as follows :—

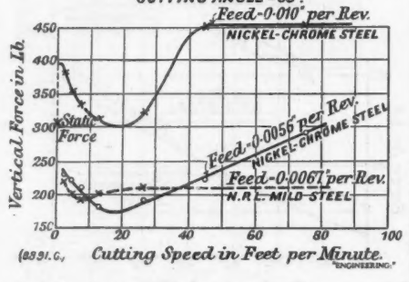
Material No.	1	2	3	4	5	6	7	8	9
Cutting angle ..	50	40	40	50	50	50	40	55	40
Ratio of thrusting force to vertical force ..	0·40	0·32	0·20	0·44	0·36	0·33	0·25	0·27	0·02

It will be seen that only in the case of material No. 9, copper, was the condition approximately fulfilled. The variation in work done per cubic inch of material removed, with cutting angles, is plotted for all the materials in Fig. 37.

The Effect of Variations in Cutting Speed on the Magnitude of the Cutting Forces.—It appears to have been fully demonstrated that for each kind of tool steel there is at least one speed of cutting at which the curve of endurance passes through a maximum value. This phenomenon has been studied closely by Mr. E. G. Herbert,* whose experiments with a special tool dynamometer have led him to the conclusion that the effect is entirely due to the rise of temperature of the tool as the cutting speed is increased. This hypothesis is solely concerned with the tool, and does not involve the conception of any change in the resistance of the material which is being cut. The possibility of changes in resistance to cutting with speed cannot, however, be entirely ruled out, and a second series of tests was made on the same materials, all with a tool of 65 deg. cutting angle, in which the horizontal and vertical forces on the tool were measured at speeds up to 80 to 120 ft. per minute. The results, when exhibited in the form of a curve whose ordinates were cutting forces and abscissæ the speed of cut, showed a quite definite minimum in the resistance in the case of two of the materials, but only faint indications of it in the others. Examples of these curves are shown in Fig. 38, for the case of nickel-chrome steel and the N.P.L. mild steel. It will be seen that at a speed of 20 ft. per minute the cutting resistance of nickel-chrome steel is only 64 per cent. of its value at 50 ft. per minute and above. On the other hand, the least resistance of the mild steel does not fall below 90 per cent. of the resistance between speeds of 50 and 100 ft. per minute.

A similar speed effect to that noted for nickel-chrome steel was found in the case of the hard-drawn

Fig.38. LATHE TOOL DYNAMOMETER. VARIATION OF VERTICAL FORCE ON TOOL WITH CUTTING SPEED. NICKEL-CHROME STEEL AND N.P.L. MILD STEEL. CUTTING ANGLE = 65°.



steel tube, the vertical force at 10 ft. per minute being less than 70 per cent. of its value at speeds between 30 and 130 ft. per minute. When, however, this material was normalised and re-tested, it was found that the speed effect had practically disappeared.

A plausible explanation of the effect in this case would appear to lie in the brittle character of the steel at ordinary temperatures, so that the shearing forces required to separate the chip from the stock would be small at these temperatures, but would probably increase at higher temperatures. This explanation, however, fails to account for the behaviour of the nickel-chrome steel which was tested under notched-bar impact, and found to be quite free from brittleness and to be fairly tough. It is possible that a marked speed effect may be characteristic of materials with a high ratio of yield stress to ultimate stress and comparatively low elongation, both of which characteristics are common in the two materials in question, and this point is being further investigated.

* "Cutting Properties of Tool Steel," Journal Iron and Steel Inst., No. 1, 1910.

DISTANT-READING TANK GAUGE.

A VERY simple gauge for indicating or recording at a distance the depth of liquid in a tank has recently been brought out by Messrs. Negretti and Zambra, of 38, Holborn-viaduct, London, E.C.1. The gauge is illustrated in Fig. 1 annexed, and its principle, which is extremely simple, will be immediately discerned from the diagram Fig. 2. A connection is made by means of small tubing between the indicating gauge and a tube submerged in the tank. An air pump with a non-return valve is connected by a branch to the main tube. If air is pumped by this means into the main tube any surplus will escape from the submerged mouth in the tank, and the air remaining will be under a pressure corresponding to the hydrostatic head H. This pressure will be indicated by the dial. In Fig. 1 the submerged end of the tube is shown as taking the form of a bell, while the hand pump is coupled to a three-way cock on the gauge. In use the cock first connects the pump and tank, and after a few strokes it is turned over to tank and gauge.

The gauge is of special design to ensure an unusual degree of accuracy for instruments of this kind. In the usual pattern either one or two diaphragms are used, with balanced parts, spring-controlled levers to prevent overloading, and pivots and gearing designed to reduce backlash and friction to the smallest amount. Hysteresis is claimed to have been reduced to a minimum. The pointer travel of the standard gauge is from 18 in. to 20 in., the dial usually being graduated 10 divisions per inch. This gives a sub-division which can be read to as small a variation of depth as ½ in. of water for tanks up to 2 ft. deep, ¼ in. for tanks 4 ft. deep, ½ in. for tanks 6 ft. and 8 ft. deep, and 1 in. for tanks 12 ft. and 16 ft. deep. The dial can be divided to read in depth, weight or volume. For accurate observation Messrs. Negretti and Zambra recommend scaling in weight since this is not affected by

Fig.1.

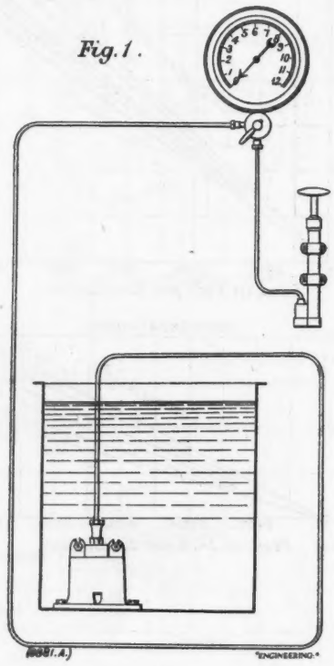
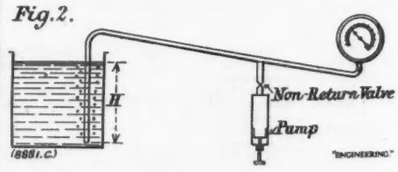


Fig.2.



temperature. The pump may be fixed to a bracket at any convenient point. The object of providing a bell in the tank is to take care of any slight leak that may occur in the connections. With a pipe of small bore, after the pump has been operated, if even a slight leak occurred the liquid would soon run back up the tube until the levels inside and out were equalised. The bell provides an air reservoir of relatively large capacity so that the gauge will indicate continuously for several days after one pumping operation. For viscous liquids such as heavy oil a length of 1-in. pipe is inserted between the bell and the main pipe, to reduce risk of blocks. The dial can be placed any distance away from the tank, up to some few hundreds of feet. The indicator can be fixed above or below tank level, and bends in the pipe have no effect upon it, neither do changes in the temperature of the connecting pipe. The firm also furnish suitable recording instruments in place of the dial, either of the circular chart type or of the continuous drum type, the clockwork being arranged for 12 hours, 24 hours, or seven days. In these cases it is best to use compressed air, the hand pump being dispensed with; a small flow of air is allowed to pass continuously to the bell, being adjusted by a small needle valve.

CUTTING TOOLS RESEARCH.

*Report on Flow and Rupture of Metals during Cutting.**

By WALTER ROSENHAIN, B.A., D.Sc., F.R.S., and A. C. STURNEY, B.Sc.

Introduction.—Recently, the interest of the Cutting Tools Research Committee of the Institution of Mechanical Engineers, has been aroused in the micro-photographic method of investigating the cutting process, and means have been provided enabling the present authors to investigate the matter.

Their main object in the present investigation has been to study the deformation and flow of metal under the action of a simple cutting tool and, more particularly, to observe the manner of separation by which the chip is formed. This object has been pursued by studying the internal structure of chips in process of formation under different cutting conditions and in different stages of development. The cuts studied have all been made on the edges of revolving discs. The cut has been stopped as suddenly as possible in order to leave a portion of the chip adhering to the stock. Subsequently sections have been cut, polished and etched through both the chip and the surrounding metal. The material operated upon, or "stock," was in the form of cylindrical bars initially 3 in. in diameter, turned down so as to leave a number of fins each 2·8 in. in diameter and 0·1 in. wide, separated from one another by slots 0·2 in. wide and 0·3 in. deep. In order to avoid any initial plastic deformation of the fins, the outer surface was removed by grinding before the experimental cuts were taken.

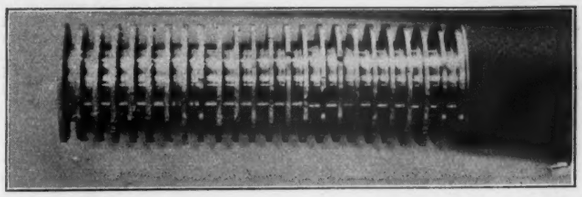


FIG. 1. STEEL BAR AFTER CUTS HAD BEEN TAKEN.

Fig. 1 shows the general appearance of a bar. The experimental cutting operations were performed with ordinary carbon steel parting tools. The cross sectional area of each tool was ¼ in. by ¼ in. All the tools employed received similar heat treatment, and their hardness, as given by the Shore scleroscope test, was about 90. The only angles which were varied in the course of this investigation were the "top rake" and "front clearance." The tool was always presented normally to the work. The speed of rotation of the bar was kept constant, so as to give a linear speed of about 50 in. per minute throughout the investigation. No lubricant was used.

Method of Taking Cuts and Preparing Specimens.—In general the method of taking cuts was as follows:—With the lathe running at the required speed, the tool was driven in to the desired depth of cut, as indicated by the micrometer feed. The lathe was stopped as suddenly as possible (assisted by braking) when the tool had nearly, but not quite, completed one circumferential cut. Each cut disc was separately sawn from the main bar, a segment containing the chip cut from the disc, and the chip, together with the area immediately surrounding it, was thickly coated with electro-deposited copper, which served to protect the edges during the subsequent sectioning and polishing processes. A transverse section was then cut through the chip in a direction parallel to the sides of the disc, *i.e.*, at right-angles to the cutting edge, polished and etched for microscopic examination.

The material used as stock for the cutting experiments were: (*a*) normalised mild steel, having the following chemical composition:—

	Per cent.
Carbon	0·142
Silicon	0·067
Sulphur	0·061
Phosphorus	0·064
Manganese	0·650

FIG. 7*a*. TEAR CHIP; BRASS. No. W.6. DEPTH OF CUT 0·030 IN. T.R. 10 DEG.

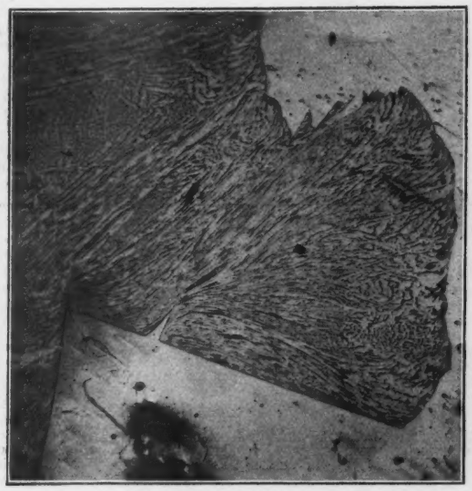
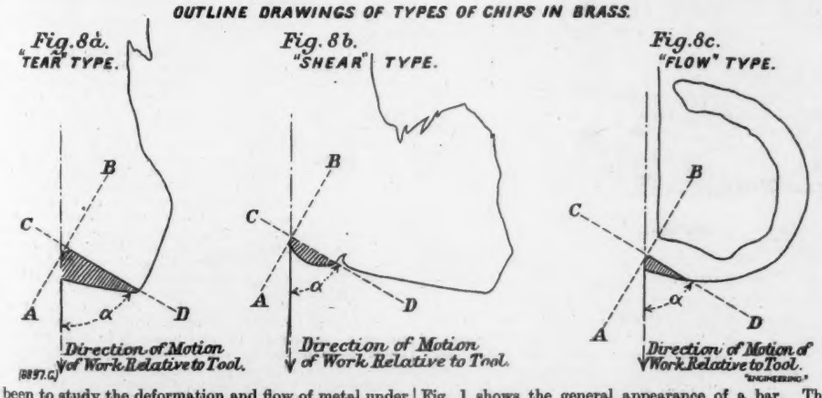


FIG. 7*b*. SHEAR TYPE CHIP; BRASS. No. W.5. DEPTH OF CUT 0·025 IN. T.R. 10 DEG.

FIG. 7*c*. FLOW TYPE CHIP; BRASS. No. W.9. DEPTH OF CUT 0·005 IN. T.R. 10 DEG.

OUTLINE DRAWINGS OF TYPES OF CHIPS IN BRASS.



* Presented at a meeting of the Institution of Mechanical Engineers, on Friday, January 23, 1925. Abridged.

and (*b*) cast brass of the 60/40 type, showing:—

	Per cent.
Copper	61·38
Zinc	38·50
Iron	0·06

Both these materials exhibit a well-marked duplex structure which facilitates the observation of deformation and flow by means of the microscope.

Examination of Shape and Structure of Chips.—A large number of cuts were taken, first, upon the steel bar; and, second, upon the brass bar. The conditions, which were varied in the case of each metal, were:—

(1) The depth of cut (from 0·002 in. to 0·05 in.).
(2) The top-rake angle (from 0 deg. to 30 deg.) of the tool.
(3) The front clearance angle (from 0 deg. to 20 deg.) of the tool.

Three general types of chip have been observed; for brief reference they may perhaps be termed: (*a*) tear type, (*b*) shear type, and (*c*) flow type, although it must not be assumed that these names are fully descriptive of the actions involved. These types are illustrated, with corresponding lettering, in Figs. 7 (*a*, *b* and *c*) and 8 (*a*, *b* and *c*). These are photomicrographs and drawings respectively of typical sections of such chips at a magnification of 40 diameters.

The "Tear" Type of Chip.—The general shape and characteristics of this type are shown in Figs. 9 (*a* and *b*) and 10. By means of these and other photographs it has been possible to follow the development of the chip from its earliest stages until its final separation from the stock. In Fig. 9*a* is seen the longitudinal

section of a chip in the process of formation, the position of the face of the tool being indicated by the thick white line. The various features of the micrograph are indicated, for clearness, by means of the outline diagram, Fig. 9*b*. Magnification, 55 diameters.

The photomicrograph, Fig. 10, shows a longitudinal

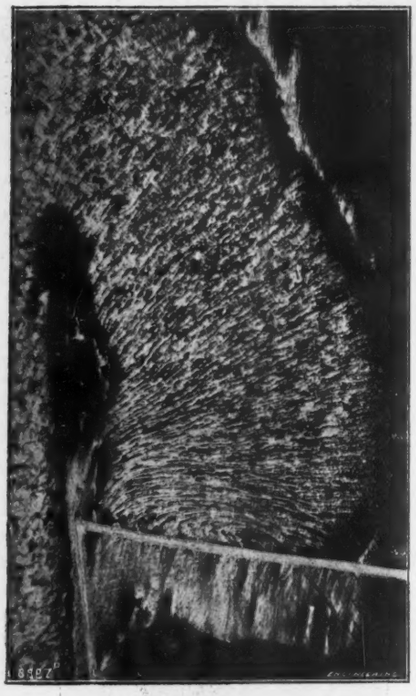
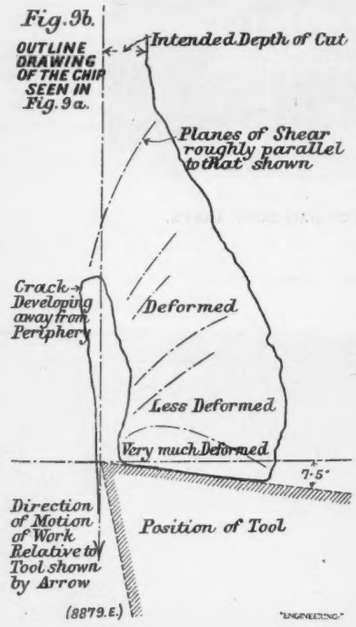


FIG. 9*a*. TEAR TYPE CHIP; MILD STEEL. NO. X21. DEPTH OF CUT 0·01 IN. T.R. 7·5 DEG.



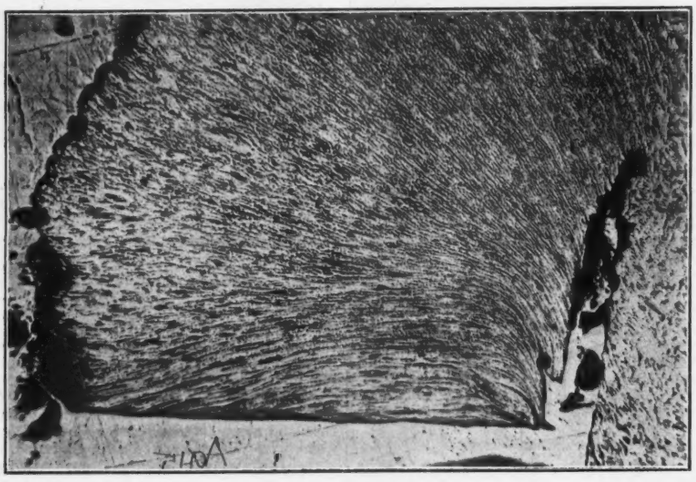


FIG. 10. TEAR TYPE CHIP; MILD STEEL. NO. Z2. DEPTH OF CUT 0·03 IN. T.R. 0 DEG.

section of another chip of the same type, at an earlier stage of its production and at a magnification of 40 diameters, which allows the distortion of the microstructure, corresponding to the flow of the metal, to be more clearly seen.

Study of such sections indicates that the mode of formation of this type of chip is somewhat as follows:—

The advance of the tool causes a local crushing and incipient shearing of the metal in front of the tool face; at the boundary of this crushed and sheared region a crack, or tear, is formed, and this tear runs forward and slightly inward (towards the interior of the stock). As the tool progresses the metal above or outside this crack is progressively further sheared and crushed. A point is, however, reached when the resistance to further tearing becomes too great owing to the increasing depth of the crack. At this point the chip shears in the direction AB, Fig. 8*a*. This shear may result in the complete severance of the chip or in a plastic displacement; in either case a fresh tear is started, and again runs forward and inward in advance of the tool. If the chip is not severed the first time, such shearing and re-starting of the crack occurs; it becomes further distorted until finally it shears off, and the whole cycle of operations is recommenced. It will be noticed that in this type of cutting, there is little or no real flow of the chip over the face of the tool or over any built-up front of the tool, although to a certain extent the part of the chip in contact with the tool face slides upwards as shearing progresses. This motion is small, but the pressure large. This type is, of course, the result of combining a relatively large depth of cut with a small top-rake angle.

The "Shear" Type of Chip.—An example of this type of chip is shown in Fig. 7*b*. In this type the tearing action is very much less marked, whilst sliding along the plane AB, Fig. 8*b*, predominates. Sliding or flow in the direction of the plane CD, Fig. 8*b* (forming the upper boundary of the greatly-deformed zone, and perpendicular to AB), also occurs, although it does not have its maximum effect in this type of chip. This type of chip is produced under conditions intermediate between those producing the "Tear" type on the one hand, and the "Flow" type on the other—for example, a small depth of cut combined with a small top-rake angle.

The shear type of chip which, from the point of view of the present research, is of an intermediate and therefore less typical character, is, perhaps, of special importance owing to the fact that in many cutting operations the aim is to produce cuttings in the form of short and detached chips rather than long ribbons or spirals. The observations showed that by reducing the depth of cut or increasing the top-rake angle or both, within certain limits, the angle at which tearing occurs in advance of the cutting edge of the tool can be altered until the tear becomes nearly tangential to the cutting circle. When this occurs, a point is reached where failure of the material occurs by shear, in the present experiments at an angle of approximately 30 deg. with the line of motion of the tool. Owing to the tilt of the material of the chip, however, this plane of shear is substantially a transverse plane of the original material. The materials used in the present experiments, being fairly pure steel and brass respectively, may be regarded as approximately isotropic. In any given material, however, the ratio between the resistance to shear on the plane in question to the other strength factors may be very different from that in the materials used in the present experiments. If this is the case, both the angle at which shear will occur and the depth of cut and top-rake angle of the tool necessary to bring it about in preference to tearing on the one hand or flow on the other, may depart widely from those found in the present series. It is well known that impurities are sometimes intentionally added to materials such as brass (lead) or steel (sulphide) for the express purpose of making them "free cutting." The effect of such impurities is clearly explained by the present observations. Their presence, particularly in rolled material, brings about a transverse weakness of the metal, particularly in regard to shear, while leaving the tensile properties longitudinally practically unaffected. In these circumstances failure by shear during the formation of the chip occurs much more readily, so that a shear type of chip results from conditions which otherwise would lead to the production of the flow type. In the present experiments the production of the shear type of chip is accompanied by a medium degree of irregularity of the cut surface. This, however, is dependent upon the ratio of shear strength to the resistance to tearing of the material, so that if shear strength is reduced while resistance to tearing is not reduced, it should be possible to obtain a shear type of chip with less irregularity than is observed in the present instance.

(To be continued.)

RESTORATION OF THE PONIATOWSKI BRIDGE.—The Prince Josef Poniatowski Bridge over the Vistula, connecting Warsaw with the suburb of Praga, which was completed in 1913, and destroyed in 1915, is being repaired. The approach to it is impressive, as one comes along the Aleza Jerozolimstea, the great street which runs straight across Warsaw to the bridge. At present it is available only for pedestrians. In September 1915, the bridge was blown up by the Russians in their retreat, when the Germans were advancing on Warsaw. Much work has been done on it recently, and it is now practically finished, and is to be opened for traffic in the Spring.

SHIP CONSTRUCTION ON THE ISHERWOOD SYSTEM.—From the time of the introduction of the well-known system of ship construction with longitudinal framing invented by Sir Joseph W. Isherwood, until the end of last year, a period of seventeen years, a total of 1,472 vessels had been built or were under construction. These consisted of 651 general cargo vessels, colliers, ore steamers, and passenger vessels; 684 oil tankers and 137 barges, dredgers, and trawlers. The magnitude of this development may be judged from the fact that the aggregate deadweight carrying capacity of these ships is 12,408,700 tons. Of the most recent contracts for Isherwood ships may be mentioned two oil tankers of 15,000 tons capacity and seven of 12,000 tons capacity, a special type of lubricating-oil tanker for the Standard Oil Company of New Jersey, and a ship of 415 ft. length, 56 ft. beam, and 37 ft. depth for the passenger and freight trade of the Southern Pacific Company of New York; two tankers of 12,500 tons deadweight carrying capacity for oil and molasses in bulk are also under construction by the Furness Shipbuilding Company, Limited, of Haverton Hill-on-Tees. A lubricating-oil tanker is being built by the Greenock Dockyard Company, Limited, for the Vacuum Oil Company of New York, while other construction includes a 7,000-ton tanker for the French Admiralty and a motor cargo liner of 8,000 tons deadweight to be constructed by Messrs. Archd. McMillan and Sons, Limited, of Dumbarton. Two Isherwood vessels, the Cabimas and the Para Guana, were recently completed by Messrs. Palmers' Shipbuilding and Iron Company, Limited, at Jarrow for the Gulf Refining Company of Pittsburgh, U.S.A., and will be used to transport oil from Maracaibo to the Carribean Sea, where they will discharge into ocean-going liners.